The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

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VOL. XVII No. 6 JUNE, 1956

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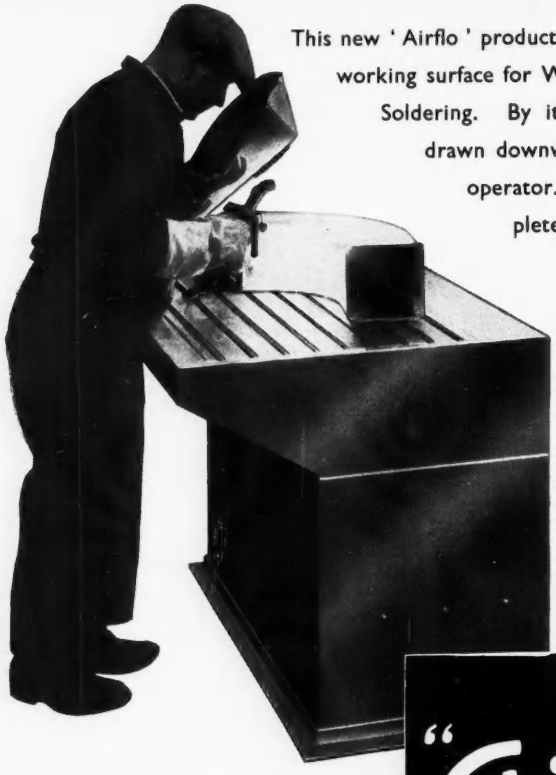

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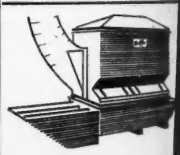

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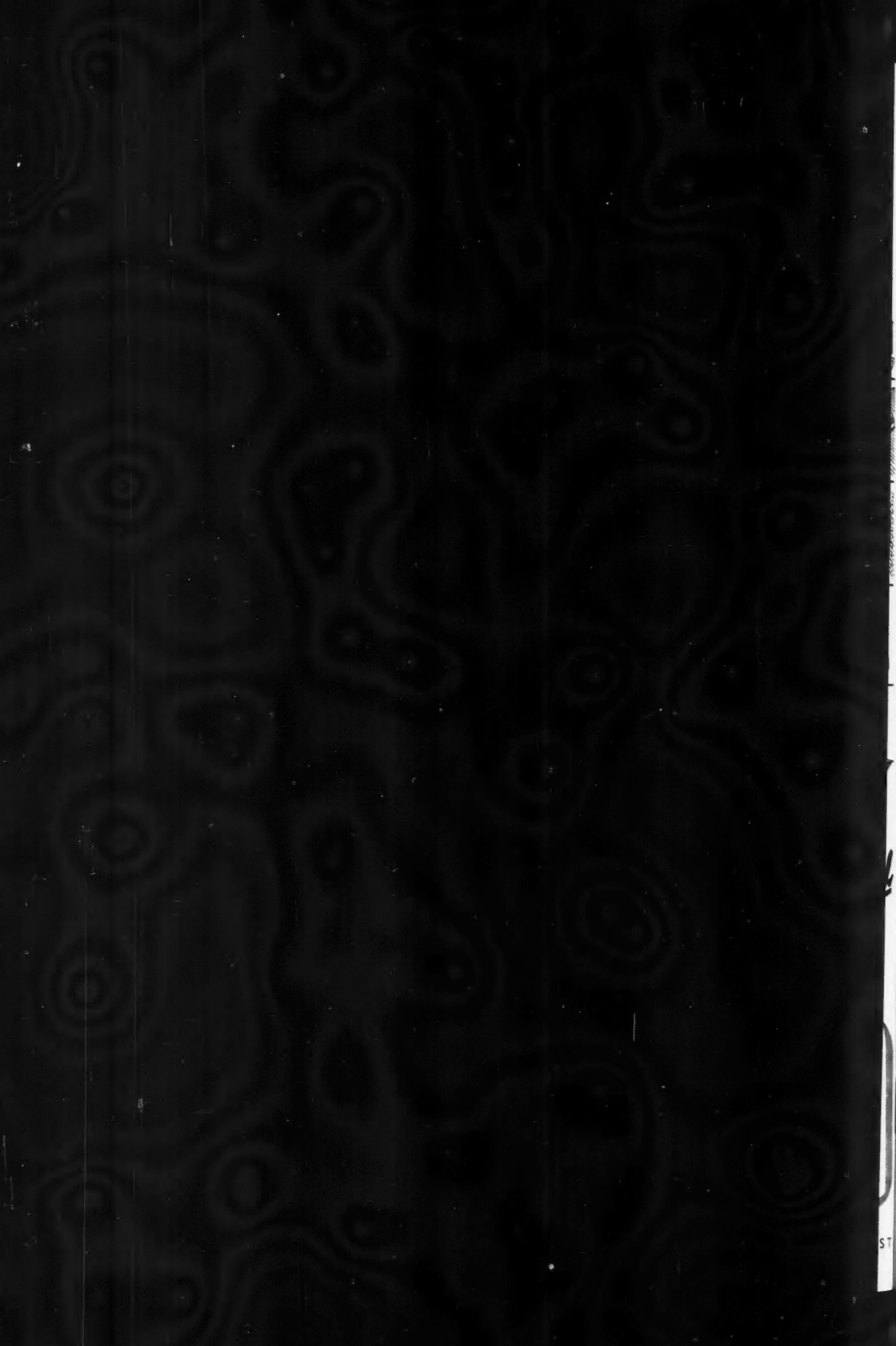


THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *NON-TARNISHABLE COPPER FINISH*

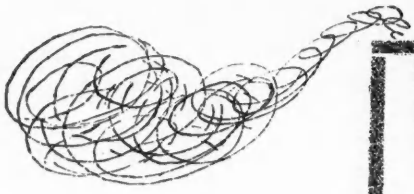
Chromate solutions have been developed in which copper and most of its alloys can be chemically polished to mirror brightness, while, in addition, the surface will resist tarnishing. Another advantage of this treatment is that chromium may be plated directly on the brightened surface without an intermediate plating of nickel. The mechanism of protection is believed to be the same as that for other metals on which chromate-conversion coatings are applied, i.e., a gel-like non-porous film which retains soluble hexavalent chromium as an inhibitor. It is stated that the protection value of the coating will vary with the type of treatment, the coating thickness, and the alloy to which it is applied. For example, in the salt-spray exposure of brass parts, the corrosion resistance increases with the zinc content of the alloy. Mirror-bright surfaces are obtainable on wrought alloys which are fine-grained and homogeneous. If the grains are coarse, the surface will be bright, but not truly flat and smooth. Heterogeneous alloys, such as leaded free-cutting brass, beta brass, and phosphor bronze, do not dissolve uniformly and consequently are not brightened as well as homogeneous alloys. Other types of chromate mixtures may be used where the copper or brass parts are to be dyed or require a higher corrosion resistance. The coatings generally exhibit low electrical resistance. However, where contact resistance or solderability is critical, a compromise on the degree of protection may be necessary, and thin films should therefore be used. It is reported that, according to preliminary tests, the spot-welding characteristics of brass-plated steels are actually improved by the use of thin films.

● *IONOGRAPHY—A NEW RADIOGRAPHIC IMAGING PROCESS*

A new process of radiographic imaging has been developed in which an electrostatic image is produced on an insulating surface. This process, which is termed ionography, is a system of X-ray imaging which is dependent upon the ionizing ability of X-ray photons. The successful use of this process requires a strong electric field produced by a fine wire mesh placed at a fixed and uniform distance above a charged plate. The radiation intensity, which is a function of the object being X-rayed, differentially ionizes the air below the wire mesh, which then discharges the plate, forming an electrostatic image. To make this latent electrostatic image visible to the eye, the plate is immersed in a liquid or air suspension of fine particles. The particles are bound to the plate in proportion to the amount of charge. A dry developing method, such as that used with xeroradiography, has been experimented with, where an insulating liquid containing a suspension of fine particles is the developer. There are several important electrical and chemical characteristics to be considered in the selection of the insulating liquid. The liquid must be a good insulator and must not dissolve or react with the plastic plate or developing powder. Success was obtained with transformer oil and carbon tetrachloride, although the latter was objectionable because of its poisonous nature. Of the many powders considered, the most favourable results were obtained with carbon black, manganese dioxide, and manganese. It may be said that the new system offers the advantage of more economical daylight inspection. Because it is still in the early stages of development, many aspects have not as yet been investigated fully. Thus, ultimate radiographic sensitivity may be limited by such factors as practical mesh and developer particle sizes.

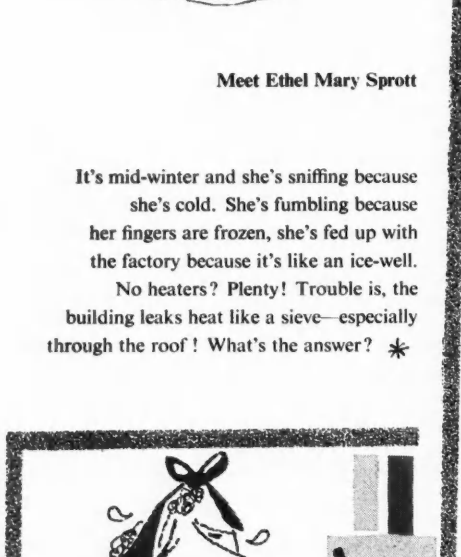
● *HIGH-DAMPING MANGANESE-COPPER ALLOYS*

Manganese-copper alloys exhibit the unusual combination of high damping capacity and high tensile strength. The relatively high damping capacity of cast iron is well known, and it is a remarkable fact that manganese-copper has more than four times the damping capacity and tensile strength of cast iron. Moreover, manganese-copper possesses excellent ductility, while ordinary cast iron has very little. A drawback, of course, is that manganese-copper alloys are considerably more expensive than cast iron and are available only in wrought form. The recently developed manganese-copper alloys cannot therefore be considered competitive with cast iron but must be considered as new materials especially suited to applications where the harmful effect of vibration and noise must be reduced. It is stated that the strength, ductility, and hardness of these alloys differ very little from those



Meet Ethel Mary Sprott

It's mid-winter and she's sniffing because she's cold. She's fumbling because her fingers are frozen, she's fed up with the factory because it's like an ice-well. No heaters? Plenty! Trouble is, the building leaks heat like a sieve—especially through the roof! What's the answer? *



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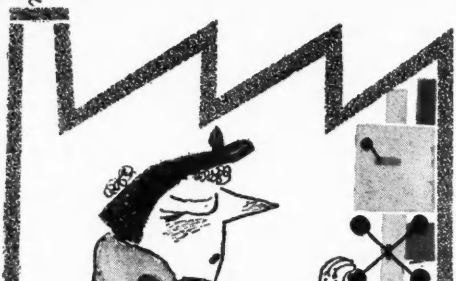

Meet Ethel Mary Sprott

It's mid-summer and she's sweating and swearing because she's hot. She's getting careless because she's drowsy. She's fed up because the factory's like an oven. What's the trouble? No windows or fans? Not on your life! Feel that roof. It's *baking* hot. No wonder production is slacking off. So what? So . . *

*wrap her in

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of normalized mild steel. However, the specific damping capacity, as expressed by the logarithmic decrement of a manganese-copper alloy of, say, 62% Mn/38% Cu is higher by a factor of one thousand. Other properties of interest of the new alloys are high electrical resistance, varying from 120 to 140 microhm-centimetres and high thermal coefficient of expansion, approximating that of aluminium. A disadvantage of these materials, however, is their tendency to ageing at temperatures above 300°C and their reduced damping capacity when used at temperatures above 150°C. There are also certain production difficulties involved, because the chemical activity of manganese causes entrapment of oxides in the molten stage. Successful casting therefore requires the use of deoxidizers, proper mould design, and correct pouring temperature.

● *PRACTICAL UTILIZATION OF LIQUID-DIELECTRIC PHENOMENA*

A systematic study of the behaviour of liquid dielectrics in strong electric fields has focused attention on several mass-transfer and optical effects which may eventually be put to practical use. These include dielectric pumps, relay switches, and a new separating technique. Among mass-transfer effects found are both liquid-dielectric rise and flow. When two solid electrodes are partially immersed in a dielectric, and a relatively intense direct potential is applied, the dielectric rises (cross-field flow) between the electrodes. If the electrodes are made of screens or sieves and are fully immersed, the dielectric flows (co-field flow) from one electrode to the other. Compounds studied so far include organic acids, aldehydes, ketones, esters, ethers, silicones, amine derivatives of aromatics, and aliphatics. As is to be expected, the magnitude of the flow or rise depends on the compound and also on its purity. Flow rates have been about 1 in. per sec in a trough about $\frac{1}{4}$ in. by $\frac{1}{4}$ in. with a power consumption of 2W. There would appear to be the possibility of building a non-mechanical pump for dielectrics, using the principle of co-field flow. An obvious application for such dielectric pumps would be for moving radioactive dielectric processing streams where remote and inaccessible locations are key design problems. A second possibility for co-field flow is to modulate a flow with a modulated voltage for sound reproduction. The current needed by a speaker actuated by such a device would be low, and the amplifier which serves it would thus not need the impedance-matching transformer required with magnetically actuated speakers. The co-field flow principle might also be used in separating devices. Relay switches are possible applications of cross-field flow, with a float actuated by the rising column of dielectric.

● *WEAR-RESISTANT ZINC-BASE DIE ALLOY*

Where small quantities of fabricated sheet-metal parts are to be produced, several materials can be used for making low-cost tools ; among these materials are reinforced plastics and low-melting alloys of lead and zinc. Short-run dies can be produced quickly and inexpensively from these materials, but often the die will wear out before anticipated production is completed. At the same time, the volume may still be too low to justify the cost of an expensive cast-iron die, so that duplicate sets of the low-cost tool must be made. It would be advantageous for the low- or intermediate-volume manufacturer to have a material available which would outwear present short-run tools by a substantial margin, yet cost little more. Since existing zinc-base tool alloys fulfil the cost and castability requirements in looking for an improved material, it was considered desirable to retain this basic composition and attempt to improve wear resistance by the addition of a dispersion of hard but relatively insoluble particles to the alloy. This addition would produce wear resistance without affecting casting quality. These hard particles would be comparable to a network of carbides in ferrous alloys, which improve resistance to rubbing wear. The hardener finally found most suitable is a ternary alloy of copper, nickel, and titanium. This alloy is composed of a dendritic network of nickel-titanium phase of the approximate relationship Ni_3Ti, surrounded by a copper-rich phase. The latter is selectively dissolved, leaving solid particles of nickel-titanium compound suspended in the zinc-base melt. When this melt solidifies, these particles are trapped and firmly held within the matrix. An optimum combination is reported to be an alloy of about 4% Al, 3·25% Cu, 0·8% Ni, 0·2% Ti, 0·15% Mg, and the balance Zn.

● *STABLE THERMOCOUPLE FOR CLOSE TEMPERATURE CONTROL*

Most thermocouple materials deteriorate when exposed to reducing atmospheres. This deterioration is accompanied by a decrease in the thermal electromotive force generated at a given temperature, so that the instrument indicates less than the true temperature. If such a thermocouple is used as a sensing device in the control circuit of a furnace, overheating of the furnace will occur. When reducing atmospheres are used for heat-treating purposes, it is therefore necessary to make a careful check of the gas tightness of the thermocouple protecting tubes and to calibrate the thermocouples at frequent intervals. Unfortunately, protective tubes can fail at high temperatures and thermocouple deterioration can be so rapid that a furnace charge may be overheated and ruined

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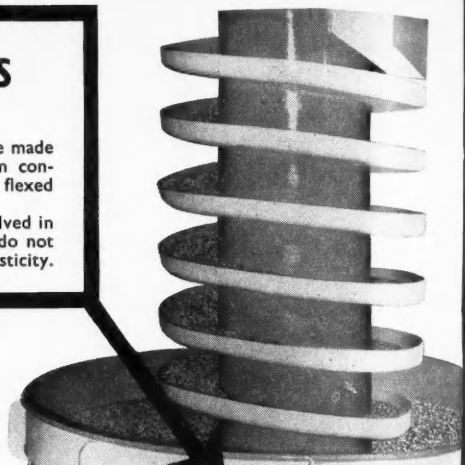

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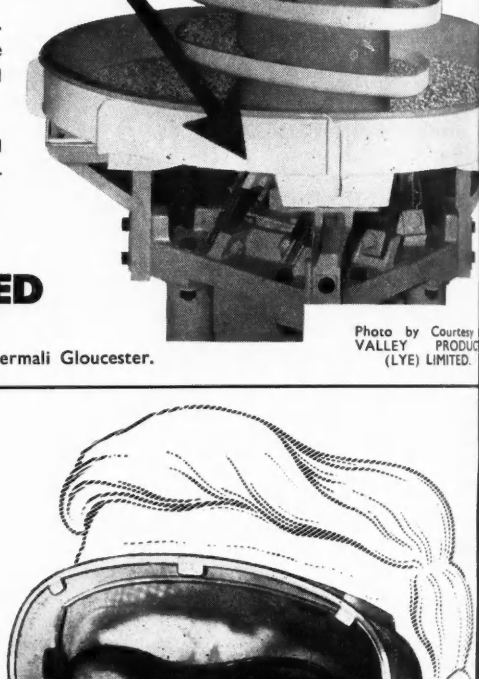

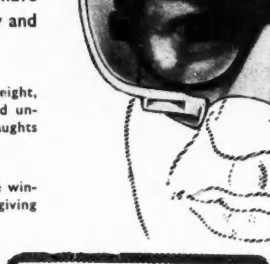

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between calibrations. Research has therefore been carried out with a view to finding thermocouples which will not only be stable in reducing atmospheres but which will also have sufficient sensitivity for the close temperature control required in heat-treating operations. It is reported that a thermocouple has now been developed which satisfies both these requirements. Although the thermal electromotive-force response of the new thermocouple is slightly less than that of other base-metal thermocouples, its sensitivity in millivolts per degree is equivalent in the higher temperature range for which it is designed. In order to determine relative stability in a reducing atmosphere, representative thermocouples of the new type were exposed in a furnace at 1750°F adjacent to a conventional base-metal couple. After an exposure of 200 hr the new thermocouple showed a small drift in the positive direction, while the conventional type exhibited a negative drift of considerably greater magnitude. The reason for these improved characteristics is believed to be the increased chromium content of the material used in the new thermocouple.

● *DIFFUSION OF HYDROGEN THROUGH CERAMIC COATINGS*

In a recent investigation into the diffusion rate of hydrogen through ceramic-coated nickel it has been found that the ceramic reduces the hydrogen flow by a factor of about twenty. These results indicate that it would be worthwhile to apply ceramic coatings to the metallic parts of high-temperature devices in order to minimize the diffusion of gases into an otherwise hermetically sealed system. In an investigation of the creep rates of ceramic-coated metals at high temperature, test specimens were exposed to various atmospheres, including hydrogen. This investigation was made in consideration of research reports to the effect that differences exist in the creep rate of bare metals in hydrogen and air respectively. This difference was attributed to the action of the oxide layer formed on the metal surface. An alternative explanation is that the metal absorbs some of the hydrogen, thus affecting the creep rate. Because hydrogen diffusion through the ceramic coatings was unknown, tests were undertaken to measure the permeability of both coated and uncoated nickel to determine to what extent the ceramic inhibits the hydrogen flow. High-purity nickel tubing was chosen for this study because it is readily permeable to hydrogen at elevated temperatures. The diffusion tests established that the particular coating examined served to reduce the diffusion rate through a specimen to at least 5% of the rate through the bare nickel, even though the thickness of the coating was only one-fortieth of that of the tube wall. Good ceramic adherence to nickel is difficult to achieve. If a chromium-containing high-temperature alloy were used in such experiments, the improved adherence and coverage of the coating would be expected to yield even lower diffusion rates than those obtained with coated nickel.

● *IMPROVED POLYETHYLENE RESINS*

New types of polyethylene resins have been developed which are more crystalline than conventional polyethylenes and consequently exhibit greater stiffness, tensile strength, and heat resistance. As crystallinity varies with density, the difference in properties is likewise largely governed by the differences in density of the various grades. The densities of two of the new materials are 0·93 and 0·94 respectively, as compared with a density of 0·92 for conventional resins and 0·93 to 0·96 for linear polyethylenes. It is reported that these new resins are not produced by the Ziegler or Phillips catalytic processes, but simply by modification of the conventional high-pressure process for polymerizing ethylene. The new resins are claimed to be nontoxic and to be essentially free from taste and odour. The original report also states that they are less permeable to gases, liquids, and greases than conventional polyethylenes, and that they have approximately the same degree of resistance to chemicals. However, powerful oxidizing agents, such as highly concentrated sulphuric and nitric acids and concentrated hydrogen peroxide, may cause the material to lose some strength on prolonged exposure. The only common solvents which seriously affect these resins are chlorinated hydrocarbons and certain aromatic and aliphatic hydrocarbons, which tend to swell and weaken the material at room temperature without dissolving it. Their good moulding characteristics make these materials suitable for a wide variety of applications, particularly in the manufacture of thin-walled products, because of their inherent stiffness. As these resins exhibit higher setting temperatures, the moulded parts can be ejected from the moulds at higher temperature, so that the moulding cycles are shortened. Their abrasion resistance is reported to be superior to that of conventional polyethylenes.

● *NEW TYPE OF BALL MILL*

Grinding speed and fineness of the discharged product from a ball mill are known to be influenced by the speed of rotation of the mill. At low speeds the ball action is mainly produced by the rolling of one ball over another and frequent impacts between balls after a drop of one or two ball diameters. This action is conducive to the breaking up of small particles and its intensity increases with the speed of rotation

Keep it off the floor!

In the production line of a factory every component has a value which increases as it passes through each process. But while it's lying about idle, waiting to be moved by hand from one place to another, its cost starts to catch up with its value until it ceases to be an asset.

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until the balls begin to fly short distances through space as they leave their position near the shell. At this stage rolling action is small, compared with the more violent impacts taking place between the balls, and the larger particles present can be broken up. If the peripheral speed of the mill were further increased, the balls would begin to fly clear across the mill and then strike the wall of the shell on the opposite side, producing extreme wear. At still higher speeds the balls are held against the shell by centrifugal force during the entire revolution and no grinding takes place. The suggestion has recently been made that, in order to increase grinding action in ball mills, Coriolis forces and precessional motion should be introduced. To obtain these it is necessary to rotate the shell about a second, vertical axis through the centre. As a result, the balls can no longer adhere to the wall even at the highest rotational speeds, and the resulting high-speed movements of the balls produce highly efficient grinding action. Good results are claimed for a small experimental mill of this type and, where mills of small dimensions for laboratory or similar uses are concerned, the new design may hold considerable promise. It is difficult to see how it could be applied to industrial mills of large output, as the forces produced by the unavoidable unbalance of the system would tend to make such a design impracticable.

● *METAL-SPRAYING WITH ROCKETS*

A new method of metallizing has been developed which uses the principle of rocket combustion. The high-temperature high-velocity jet leaving the rocket nozzle is used to melt and atomize a metal wire which is fed through the rocket throat, the atomized metal being sprayed onto a prepared surface. With this new type of metallizing gun, the spraying procedure remains essentially the same as that used in present commercial metallizing methods, but the new method is claimed to have the advantage that it is possible to control the average particle size over the wide range of 20 to over 200 microns. The major difference between the two types of units is in the method of heating and atomizing the wire. The air-blast gun utilizes an open oxy-fuel flame to heat the wire, and a stream of compressed air atomizes the molten metal. The use of rocket energy to perform these functions obviates the use of the compressed-air system. The rocket metallizer is not suitable for use with acetylene, which is unsafe when used at gauge pressures over 15 psi. Propane and similar fuels are therefore used instead. Oxygen and propane are led through pressure regulators at 100 and 115 psi respectively, and are forced through injectors into the combustion chamber of the rocket. The combustion temperature is about 5400°F and the exit gases composing the jet travel at a velocity of nearly one mile per second. That the temperature of the jet is over 5000°F is proved by the fact that the flame melts molybdenum, which has a melting point of 4750°F. The critical part of the metallizing rocket is its throat, which must have the correct cross-sectional area so that the wire can be heated to the desired temperature and still allow the gases to retain sufficient kinetic energy for adequate atomization.

● *METER FOR SHOCK-VELOCITY MEASUREMENTS*

A barium titanate velocity meter has been developed for use in shock-damage tests aboard moving ships or aircraft. Unlike most instruments used in such tests, the device has a sensitive axis which can be used at any angle without adjustment. Other design features include a uniform velocity response down to 1 cm/sec and a practically unlimited displacement range. Development of the barium titanate velocity meter was undertaken to overcome certain deficiencies of meters in present use which measure shock velocity directly. These velocity meters consist of a heavy-mass spring mounted to a rigid frame attached to the test structure. When the test structure and frame are accelerated, the mass remains fixed in space for a small fraction of the natural period of the spring-mass system. As a result, during this short time interval, the displacement of the mass relative to the frame is equal and opposite to the absolute motion of the frame. This relative motion causes a pick-up coil to cut the lines of force of a constant magnetic field, so that a voltage is generated. The voltage is proportional to the relative velocity between the mass and the frame and therefore, for a limited time, is proportional to the absolute velocity of the frame. Large errors may be introduced in the spring-mass system if the instrument is used with its sensitive axis other than vertical. These disadvantages are claimed to be avoided in the new meter, which contains a group of four barium titanate piezoelectric transducers, each 3 in. in diameter and $\frac{1}{8}$ in. thick. The range of the instrument is reported to be at least ± 300 *g*. The effect of the inherent temperature sensitivity of the barium titanate is reduced to negligible proportions by minimizing both radiation and conduction heating of the sensitive element.

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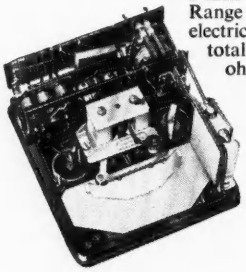

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Van de Graaff High-Voltage Generator with a Liquid Transport Medium

By K. JANNER, S. MAGUN, and E. SCHOPPER. (From *Zeitschrift für angewandte Physik, Germany*, Vol. 7, No. 9, 1955, pp. 446–450, 5 illustrations.)

THE principle of the van de Graaff generator[1], i.e., the mechanical transport of electrostatic charges, allows high voltages to be produced with a comparatively small outlay of equipment. The delivery current or quantity of electricity transported per unit time is limited, however, by the features of the transport mechanism. In the usual belt-type generators with specified belt width and belt velocity the limiting factor is the charge density arriving at the collector electrode. This in turn is limited by the field strengths of the installation and the breakdown strength of the media subjected to these fields.

The requirements are, therefore, avoidance of high peak values of field strength on the transport path, and confinement of fields within media having a high dielectric strength. Attempts have been made in the past to obtain improvements along these lines by controlling the potential along the path of the belt[2], providing for transport of opposite charges with combined tracking of the two belt portions[3], and pressurization of the casing filled with a suitable gas[2].

A possibility of fulfilling the above requirements in an ideal manner is presented by an arrangement in which two coaxial insulating cylinders are charged with equal and opposite quantities of electricity. If the cylinders are moved axially in opposite directions, so as to obtain relative motion, charge transportation takes place. The process can be made continuous by using a liquid transport medium, as indicated in Fig. 1. The liquid medium is circulated in the annular spaces between concentric cylinders by means of a pump. Means of charging and charge removal are provided at the ends of the cylinders. With this arrangement, the field of the charge along the transport path is situated entirely within the liquid and the intermediate wall.

A totally enclosed generator for 1 MV could be designed with the following data :—A spherical electrode of 40 cm in diameter is enclosed in a spherical casing of 80 cm in diameter, with high-pressure air as the dielectric. This unit has a capacitance of about 40 pF. Hence, the field strength at the electrode is 10^5 V/cm. If the electrode and casing diameters were 50 and 100 cm respectively, the field strength would be $0{\cdot}8 \times 10^5$ V/cm. For this application, air at a pressure of 12 atm gauge should be sufficient as a dielectric. If a belt transport system were contemplated, this would require a casing approximately 50 cm larger in diameter, with mechanical stresses twice as high as in the present case.

When a liquid or gaseous transport medium is employed, the high-voltage electrode can be fitted on an insulating tube section, which, in addition to being provided with channels for the transport medium, may also contain an X-ray tube or a particle accelerator.

If the value of 10^5 V/cm is accepted for the field strength in the transport medium, due to the space charge, then a rough estimate gives a corresponding charge density of $\rho = 2{\cdot}7 \times 10^{-8}$ coulomb/cm^3 for the transport medium in two concentric hollow cylinders, with 14 cm diameter for the outer cylinder and 1 cm wall thickness. For a flow velocity of 5 m/sec, this would correspond to a current of about 1 mA.

The use of a gaseous transport medium in a high-voltage generator was described by Pauthenier and Moreau-Hanot[4] in 1937. In their generator, the air stream, carrying charged dust particles, was circulated in a closed tube. The charge was removed from the particles inside the collector electrode by allowing the particles to slide over suitably curved baffles. The generator, with an electrode voltage of 1·2 MV relative to earth, produced a current of 0·035 mA. The channel diameter was 10 cm and the flow velocity 50 m/sec. From these figures, the space charge density obtained is $8{\cdot}8 \times 10^{-11}$ coul/cm^3. Its true value is probably somewhat higher, since no account has been taken of losses due to the relative motion of the particles in the air stream or of those due to brush discharges and conductivity.

It can be estimated that, to obtain a current of 1 mA, it would be necessary to increase the cross-section of the channel to 53 cm in diameter ; this would require a blower of a fairly large size. Pauthenier mentions a blower power of 30 kW for an effective current of 0·5 mA at 5 MV. In this machine, evidently the space charge density was adversely affected by the mobility of the charge-carrying particles. The authors of the present investigation decided, therefore, to consider liquid substances as transport media for their tests.

TRANSPORT ARRANGEMENT

The transport arrangement is shown schematically in Fig. 1, and consists basically of three concentric insulating cylinders, in which the transport medium flows in a closed circuit. The charging device is represented by an earthed wire spiral *A* and a corresponding annulus *B*. If the latter has a sufficiently high positive potential, the liquid medium will become negatively charged as it flows through this lower section. Removal of the charge occurs at the upper end along the deflectors and the wall surface ; however, before reaching this section, the liquid transfers a portion of its charge to an annulus *C*, which is connected by a brush-discharge path to the collector electrode. The wire spiral *D* is conductively connected to a Faraday cage, not shown in the figure. The voltage between *C* and *D* can be adjusted by altering the discharge path. If this voltage is sufficiently high, the transport medium flowing downwards will become posi-

tively charged. This charge is removed from the returning liquid at the pump end, which is earthed, after a partial transfer to annulus *B*, which is thus provided with the necessary potential for the charging of the flow in the upward direction. The potential between *A* and *B* can also be adjusted by varying the brush-discharge path.

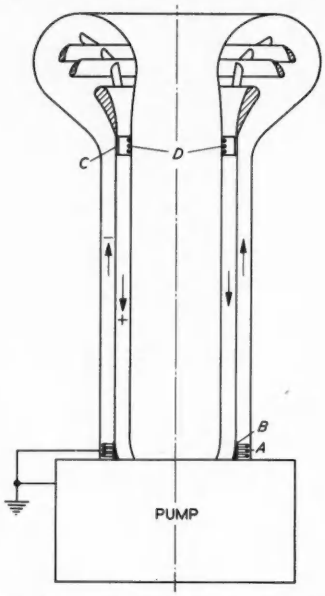

Fig. 1. Basic features of a liquid-transport type of high-voltage generator, with arrangements for charging and charge removal.

The estimated values given below are for an arrangement consisting of three cylinders 50 cm long, with outer diameters of 14·5, 12, and 19 cm respectively, and wall thicknesses of 0·5 cm. On the basis of the model tests carried out, it can be expected that, with transformer oil as the transport medium, circulating at a velocity of 5 m/sec, the current will reach a value of 1 mA.

With regard to the properties of the transport medium, it may be noted that the electrical resistance, dielectric constant, and breakdown strength should have high values, whereas the mobility of the charge carriers and the energy transformations in the medium should be small. Low wall-friction losses could be obtained with thixotropic substances, which are capable of a reversible sol-gel transformation. However, for the tests transformer oil was used.

A good transformer oil has a breakdown strength of $1{\cdot}8 \times 10^5$ V/cm. With an extremely high degree of purity, values of about 5×10^5 V/cm have been reached. As regards conductivity, Toriyama[5] found a value of 10^{-11} mho for a field strength of 3×10^5 V/cm and an electrode distance of 3 mm ; the conductivity was still one third of this value for a field strength of 4×10^3 V/cm. According to Nikuradse[6], up to a value of $0{\cdot}2 \times 10^5$ V/cm, conductivity is proportional to the field strength.

If a current loss I of 0·001 mA from the collector electrode to earth through the transport medium is taken as an acceptable figure, the cross-sectional area A of the transport liquid, at 10^6 V and with a transport path of 50 cm, can be obtained as 500 cm².

Thus, in practice, the cross-sectional area will not be limited by the inherent conductivity of the transport medium.

The losses due to the mobility of the charge carriers in the transport medium can be estimated as follows. The mobility of ions in aqueous solutions is of the order of 10^{-4} cm/sec V for reasonable values of field strength. According to Stokes law, ion mobility is proportional to viscosity ; in oil, therefore, it is of the order of 10^{-6} cm/sec V. In view of the decreased viscosity with heating, the calculation was made with a value of 10^{-5} cm/sec V. Accordingly, the relative velocity of the ions in the liquid is of the order of 1 cm/sec for a field strength of 10^5 V/cm, whereas the flow velocity of the oil is 5 cm/sec and the transport over the 50-cm path takes only 0·1 sec.

The loss through a counterflow of ions is therefore negligible. It would be possible, however, for 10% of the total charge to flow out into the wall if the thickness of the oil layer in the transverse direction were 1 cm. In an arrangement such as that shown in Fig. 1, charges would accumulate on both sides of the intermediate wall until finally a spark discharge occurred. This may not have a detrimental effect if the insulating capacity in the longitudinal direction is not diminished. A discharge can be avoided, however, if the conductivity of the intermediate wall is increased in its transverse direction, e.g., by the provision of small passages through which these charges can compensate each other. These passages can be filled with a material of greater conductivity than the wall material.

The use of a liquid medium for the transport of the electric charge is, of course, legitimate only if the expenditure of mechanical energy is also within reasonable limits. The efficiency of the installation can be assessed from a consideration of the losses in terms of power, as follows :—

The total power loss N_L consists of losses in the charging of the transport medium N_C, losses of charge during transport N_T, insulation losses N_I, and frictional losses, N_F, so that

$$N_L = N_F + N_T + N_C + N_I.$$

With regard to frictional losses, the flow in a tube is laminar for Reynolds numbers of less than 2320 ; above this value it is turbulent. The effect of an electric field on the flow of the charge-carrying medium will be disregarded. In turbulent flow, the swirling of the liquid causes a continuous change of polarity of the individual liquid elements and, owing to their inertia resistance to polarity changes, has the effect of an increase in viscosity of the liquid. Consequently, the change-over from laminar to turbulent flow will take place only at a higher value of velocity. The effect on the flow conditions of the movement of ions in the liquid is not considered in the following. For an outer cylinder of 14 cm o.d. and 12 cm i.d., with a flow velocity w of 5 m/sec and assuming the kinematic viscosity ν of transformer oil at 27°C to be 0·08 cm²/sec, the Reynolds number is approximately 12,500. For the inner cylinder, of approximately 11·5 cm o.d. and 9 cm i.d., the Reynolds number is about 14,900. Thus, turbulent flow is obtained in both channels.

Furthermore, if A = cross-sectional area of the tube, and Δp = pressure loss of the entire channel, the frictional loss is

$$N_F = wA\Delta p.$$

For a straight tube section

$$\Delta p = \lambda L \gamma U w^2/(8Ag)$$

where λ = coefficient of friction, γ = specific weight of liquid, g = acceleration due to gravity, L = length of transport path, and U = mean tube periphery. According to Blasius, for a smooth tube and Re between 2320 and 200,000, the coefficient of friction λ can be taken as $0{\cdot}316/\sqrt[4]{\mathrm{Re}}$. Therefore, in this range of Re-numbers,

$$\Delta p = 0{\cdot}158\gamma L\, w^2/(g\, d\sqrt[4]{\mathrm{Re}})$$

As the transport path is 50 cm long, the pressure loss for the outer cylinder of liquid (with $d = 4A/U = 2$ cm) is

$$\Delta p_1 = 0{\cdot}076 \ [\mathrm{kg/cm^2}]$$

and similarly for the inner cylinder, with $d = 2{\cdot}5$ cm,

$$\Delta p_2 = 0{\cdot}073 \ [\mathrm{kg/cm^2}]$$

For the deflecting section in the Faraday cage, the loss in the bend can be calculated with the usual formula

$$\Delta p = \eta\gamma w^2/(2g)$$

where η is a non-dimensional design factor. With $\eta = 0{\cdot}5$, this gives $\Delta p_3 = 0{\cdot}051$ [kg/cm²].

Finally, taking this same value for the pressure loss Δp_4 in the sections connecting to the pump at the bottom end of the duct system, the total pressure loss of the entire transport arrangement is

$$\Delta p_F = 0{\cdot}25 \ [\mathrm{kg/cm^2}].$$

This corresponds to a frictional power loss N_F of 0·5 kW.

The effective power required is

$$N = 0{\cdot}9\, V_E\, (\rho_1 A_1 w_1 + \rho_2 A_2 w_2) = 1 \text{ kW},$$

where the factor of 0·9 assumes that 10% of the space charge is lost over the transport path, $V_E = 1$ MV = electrode voltage, and $\rho_1 = \rho_2 = 2{\cdot}7 \times 10^{-8}$ coul/cm³ for both transport paths. A_1 and A_2 are the channel cross-sections, and $w_1 = w_2$ = flow velocity.

The ions migrating in the liquid pass on average through a potential difference of about half the voltage V_C occurring in the excitation circuit between the two electrodes. As the ions are slowed down considerably by the transport medium, the energy thus gained is converted into heat. The same amount of power is required in order to bring the charge carriers back to earth potential in the charging arrangement at the lower end (for the effective power, the voltage between earth and the Faraday cage should be taken). For $V_C = 50$ kV and a current of 1·1 mA, therefore, the power loss for the upper and lower charging arrangements is approximately

$$N_C = (4V_C\, I)/2 = 0{\cdot}1 \ [\mathrm{kW}]$$

If the current density of the charge flowing into the wall is constant and the potential increases linearly, then, with a 10% loss of charge, the transport loss is $N_T = 0{\cdot}055$ kW. The insulation losses N_I are negligibly small in comparison. Assuming an efficiency of 60% for the pump and the motor, the overall efficiency of the installation is

$$\eta_{\mathrm{tot}} = 0{\cdot}6\, N/(N + N_L) \cong 35\%.$$

The pump in this application has to deliver 20·4 litres/sec against a pressure of 0·8 kg/cm², requiring a power of 2·4 kW.

The major portion of the losses is thus attributable to the frictional power loss which, for the hollow cylinder, can be evaluated as

$$N_F = 0{\cdot}04\, L\, U\, \gamma\, w^3/(g\sqrt[4]{\mathrm{Re}})$$

This equation also contains the variables which are of primary importance for the losses in the deflecting sections. The transport length cannot be made smaller, owing to the danger of a breakdown along the tube walls. A decrease in periphery would result in a corresponding reduction of the effective power output. The influence of $\sqrt[4]{\mathrm{Re}}$ is very small. As the expression for the effective power is linearly proportional to A and w, whereas N_F is a function of w^3, it would be possible to decrease the frictional losses without altering the power output by reducing the velocity and using a larger cross-section. Owing to the specified limit for the field strength, however, and the value of the space charge related to it, an increase in the flow cross-section could be achieved only by increasing the periphery U or by fitting inside each other a larger number of hollow cylinders of alternating polarities. However, while in a belt-type generator the outer dimensions are proportional to the belt width, in the liquid-transport generator these dimensions are proportional to U/π.

Charging of the Transport Medium

There are various possibilities for the charging of the transport medium, and these can be summarized as follows :—

(a) Separation of charges in the medium itself, through removal or neutralization of one type of charge carrier. This is obtainable, for instance, by ionization of the liquid in a strong non-homogeneous field (Fig. 1) ; by ionization of particles contained in the liquid and separation by a strong electric field ; or charging by separation of charges at boundary surfaces.

(b) Charging by injection into the transport medium of charge carriers of one polarity only, e.g., charging by means of a gas discharge ; charging by electro-dialysis ; and charging by a combination of these two methods.

It is of interest to consider one arrangement for each of these two groups.

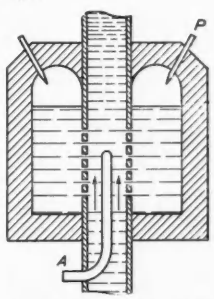

Fig. 2. Arrangement (3/4 full size) for charging of the transport medium by means of a gas discharge.

For the charging of the liquid transport medium by charge separation in a strong non-homogeneous field, an electric field is generated between a cylindrical electrode and a thin wire situated along its central axis. This field causes an ionization of the transport medium in the vicinity of the wire. Ions migrating towards the wire have only a short path to cover in a field of increasing intensity ; the reverse conditions apply for ions of opposite polarity. These can therefore be carried away by the flow if the flow velocity of the transport medium is correctly chosen, whereas the others become neutralized on reach-

ing the wire. Thus, the liquid is electrically charged when it has passed through this system of electrodes.

The charging of the transport medium can be obtained by means of a gas discharge, as follows :—The transport liquid is contained in the tube and also, through perforations in the tube walls, in the lower part of an annular chamber surrounding the tube, as indicated in Fig. 2. In this chamber, the level of the liquid is such that the gas situated above it has no connection with the interior of the tube through the perforations in the tube wall. If a sufficiently high potential difference is generated between the electrode *A* and the points *P*, a discharge will develop in the gas space. Ions of opposite polarity to that of the electrode *A* will pass into the liquid and be carried away after passing the tube wall. The perforated tube section serves to prevent any outflow of gas. In exploratory tests of the arrangement in Fig. 2, a current of 0·002 mA was obtained, with an excitation voltage of 25 kV.

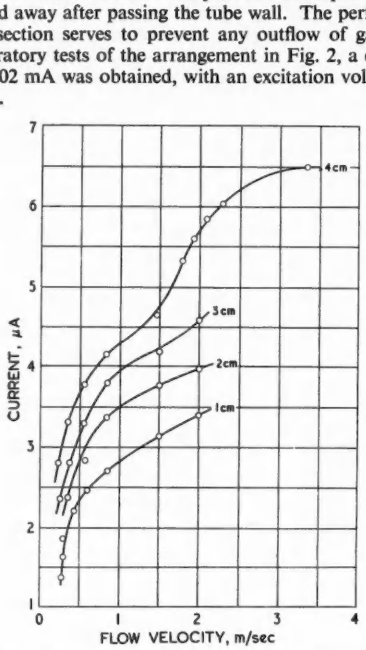

Fig. 3. Curves of current as a function of oil flow velocity when charging in a cylindrical field, with an excitation voltage of 21 kV and for different lengths of cylindrical field.

(c) Self-excitation. Whether the oil is charged in a non-homogeneous field or by a gas discharge, in the ideal case there is no flow of current between the two electrodes i.e., the insulation losses need not be taken into account. In principle, it would thus be sufficient to charge the electrodes once only, and the earthed wire or the point-type electrodes would then ensure a continuous supply of charges to the oil, provided that these charges are continuously and completely entrained by the transport medium. The energy required for the charging of the liquid (apart from the work expended in charge separation) is thus not taken from the excitation circuit but from the kinetic energy of the transport medium. Consequently, if the insulation losses are low, it should be possible to construct a self-excited machine in which charge separation is obtained with the aid of the flow of the transport medium through a nozzle of suitable material. Once a space charge has been created in the liquid, a portion thereof can be diverted to the electrodes to compensate their charging losses, which rise with increasing values of space charge.

The basic considerations are the same as for the self-excited belt-type generators of Neubert,[7] Kossel[8], and Heise[9]. The charge can be removed from the transport medium, as in previous systems, by passing through a Faraday cage in which the field of the space charge causes a migration of the charge carriers onto the wall.

Experimental Investigation of the Charging Process

To explore various possibilities, a comparatively large number of arrangements was built and tested. Figs. 3 and 4 give some of the experimental values obtained with a simple system for charging in a non-homogeneous cylindrical field. The oil was circulated by means of a pump in a closed circuit, and the transport medium between the charging device and the discharging vessel passed through a glass tube of 10 mm i.d. and 1·4 m in length.

Fig. 3 shows the dependence of current on the length of the charging cylinder for an excitation voltage of 21 kV. The pump delivery was approximately 240 cm³/sec. With

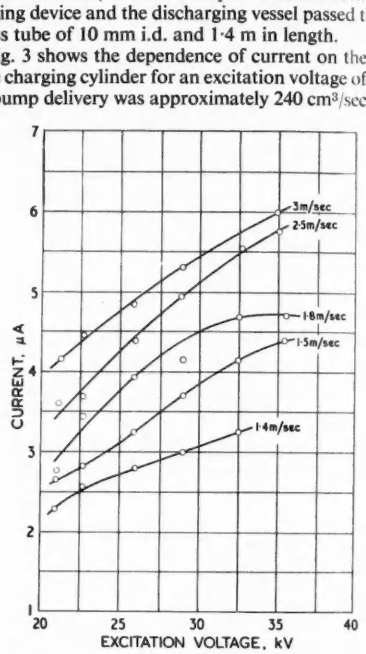

Fig. 4. Curves of current as a function of excitation voltage when charging in a cylindrical field, with a length of cylindrical field of 3 cm and for different oil flow velocities.

the oil flowing at a velocity of 3 m/sec, the current obtained was 6μA, corresponding to a mean space charge density of about $2{\cdot}3 \times 10^{-8}$ coul/cm³. Applied to the arrangement which was the subject of the above estimations, these results permit the expectation of a current of 1 mA. It is considered that the 1-MV generator with this current can be accommodated in a pressure vessel or a vacuum-type container of 1 m in diameter and about 1·5 m in height.

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The Application of Superheated-Vapour Atmospheres to Drying

By A. M. Lane and S. Stern. (From *Mechanical Engineering*, Vol. 78, No. 5, May 1956, pp. 423–426, 8 illustrations.)

The unique advantages of using superheated vapours, especially superheated steam, as a drying medium have long been recognized ; however, early attempts at commercial application were hampered by the unavailability of equipment suitable for superheated-vapour operation.

The most obvious advantage of superheated-vapour drying is its heat economy compared with ordinary air drying. In air drying, the evaporated moisture and air mixture leave the drier at the same temperature, and each represents a definite quantity of heat. In an ideal superheated-vapour operation, only the evaporated moisture leaves the drier. Therefore, the heat represented by the air is not required, and a net reduction and saving in heat requirements are achieved. Comparisons of theoretical heat consumption by adiabatic air drying of water and when drying with superheated-steam vapour clearly show the advantage of the latter. Similarly, in the case of evaporation of benzene in an air drier and in a drier using superheated-benzene vapour, the latter shows a marked reduction in heat consumption.

Superheated-vapour operation also has the advantage over air drying that increased coefficients of heat transfer are obtained. This has been shown by Wenzel and White[1] and by Chu, Lane, and Conklin[2]. In superheated-vapour drying the inert-gas film resistance to heat transfer is eliminated, and thereby heat-transfer coefficients are increased. Increased heat-transfer coefficients for superheated-vapour operation generally mean that smaller drying equipment can be used.

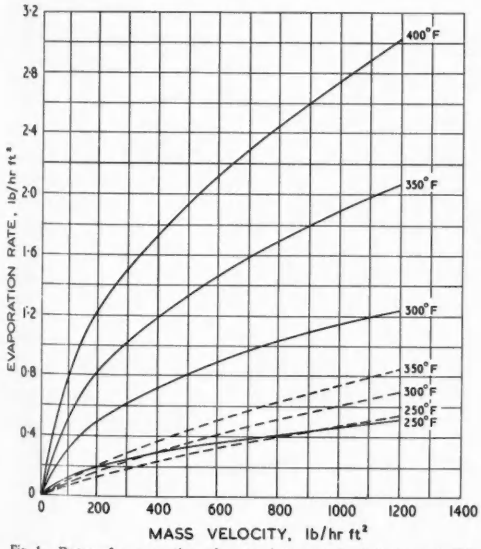

Fig. 1. Rates of evaporation of water into superheated steam (solid curves) and into air (dotted curves).

Fig. 1 shows the rate of air-water drying and superheated-steam drying. Fig. 2 shows the same data for benzene evaporation. It is readily apparent that, except for operating temperatures near the saturation temperature, the rate of drying for superheated-vapour operation exceeds that for air drying. Drying ceases for superheated-vapour operation when the temperature of the vapour is at the boiling point of the liquid. In an air-drying operation, drying will cease when the air becomes saturated with the vapour. This imposes a limitation on the applicability of drying temperature-sensitive products with superheated vapours. It therefore follows that superheated-vapour drying is applicable only for materials which have a temperature limit above the boiling point of the liquid being evaporated.

Aside from the advantages of greater heat economy and reduced size for drying equipment, owing to higher drying rates, there are several advantages which can be ascribed to the absence of air or oxygen from the drying system. Materials which are ordinarily oxygen-sensitive when dried in air at elevated temperatures can be dried successfully by employing an atmosphere of superheated vapour. Where it is necessary to remove an organic solvent from the solid being dried, very careful consideration must be given to the explosion hazard. Drying in an atmosphere of the superheated-solvent vapour eliminates air from the system and is, therefore, one of the ways in which the explosion hazard can be eliminated.

In ordinary air-drying installations the ever-present problem of dust losses and resulting atmospheric pollution has been causing increased concern. In most types of continuous driers, the material is either tumbled through the air stream, or the air is passed through the bed of material. Large quantities of air travelling through

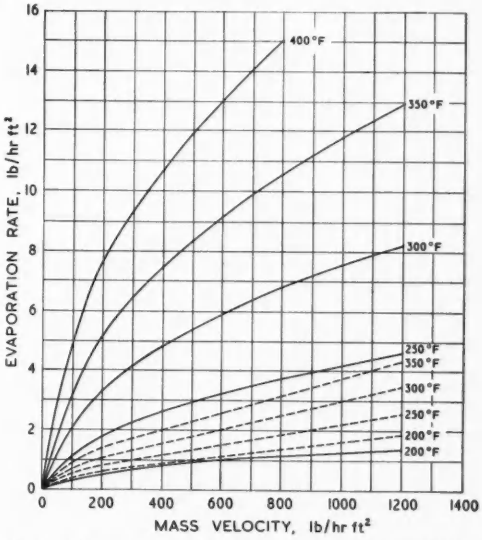

Fig. 2. Rates of evaporation of benzene into superheated-benzene vapour (solid curves) and into air (dotted curves).

the material at high velocity can create a significant dust problem, including that of the dust-explosion hazard.

However, in superheated-vapour drying the only gases leaving the drier are the vapours generated from the moisture in the material. This reduced flow is in itself enough to keep dust carry-over with the vapour exhaust

so small that superheated vapour can be vented to the atmosphere without fear of atmospheric pollution. When no atmospheric pollution can be tolerated, the exhaust vapours can be sent to a total condenser, where the small amount of dust is collected with the condensate and filtered out for recovery, if desired. Condensation of the vapours offers the obvious advantage of being able to recover completely the moisture evaporated during drying.

Schemes of Operation

References in the literature[3] have been made to driers employing superheated vapours, where recovery of the vapour was of prime importance. In the case where wool or leather has been degreased with naphtha, it was found most convenient to circulate a current of superheated-naphtha vapour through the material. The liquid naphtha is vaporized and carried out of the drier to a condenser, leaving the dried material practically free of naphtha.

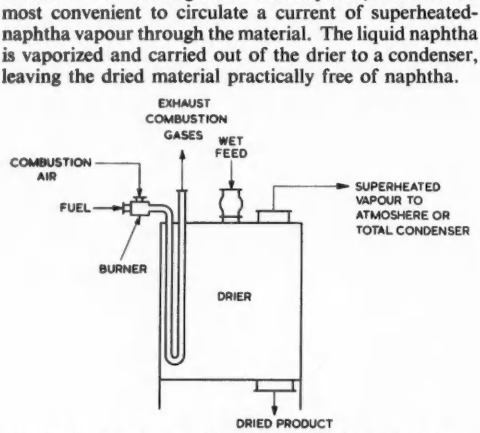

Fig. 3. Superheated-steam drier with internal radiant-tube heaters.

It also has been proposed that superheated vapours be used as the heat-transfer medium in spray-drying of solutions or emulsions.[4] However, little work has been done to prove one way or another the practicability of such equipment. At the present time, however, a great deal of work is being done on superheated-vapour drying techniques, using a continuous-tray drier of the turbo-type. Fig. 3 shows a pilot-plant installation of a turbo-type drier which has been in operation for several months. Rates of drying are two to three times those observed when drying with air at equivalent temperatures. Superheated steam at atmospheric pressure and temperatures from 300 to 450°F has been employed as the drying medium.[4] The superheated-steam atmosphere is generated from the moisture in the material. The materials tested in this unit were micron-sized inorganic materials with high-temperature limits. When filter cakes of these materials are dried in air they tend to disintegrate and form extremely fine dust. However, when dried with superheated steam the pieces of filter cake show little tendency to fall apart or form dust. In this installation the superheated exhausted vapour is sent directly to atmosphere without any apparent dust loss.

Heat is provided by burning gas in four U-shaped radiant-tube heaters located in the space between the drier housing and the rotating trays. Turbine-type fans located within the drier are used to circulate the drying medium over the material. As a result, there is no pressure drop across the drier because of circulation of the drying medium. The turbo-type drier, therefore, operates at pressures very close to atmospheric pressure. Leakage of air into the unit or solvent vapours out of the unit is prevented without elaborate sealing devices. When the liquid being vaporized is an inflammable organic solvent which is to be recovered, steam-tube heaters can replace the radiant-tube heaters within the drier. The superheated-solvent vapour is exhausted to a total condenser for complete recovery of the liquid.

In a drier installation scheduled to go into operation in 1956, an organic solvent is to be vaporized from an organic solid. The heat is to be provided by steam-tube heaters using high-pressure steam. The steam temperature is, however, above the melting point of the solid, making it necessary to locate the heating elements outside the drier, where they cannot be fouled by dust which might be blown against them. The preheated organic solvent vapour is introduced into the drier at several levels through a vertical manifold duct. By controlling the quantity of superheated vapour introduced at each inlet, the temperature in each zone can be controlled. The circulation of the vapours over the material is constantly maintained by the internal turbine-type fans. A quantity of vapour equivalent to the preheated vapours introduced, plus the solvent evaporated, is exhausted through a wide-area exhaust breeching, where any dust present settles back into the drier. The vapours are then passed through a recirculation fan to a partial condenser, where the solvent evaporated is condensed out. The condenser has been designed to act as a scrubber to remove any traces of dust in the vapours before the uncondensed portion is returned to the reheater and then to the drier.

Where the solid has a low melting point but is not dusty, greater heat economy can be obtained by arranging the recirculation stream as shown in Fig. 4. The exhaust is split into two streams. A portion equivalent to the solvent vaporized is sent to a total condenser for recovery. The remainder of the superheated solvent-vapour exhaust is sent to the reheater and then back into the drier.

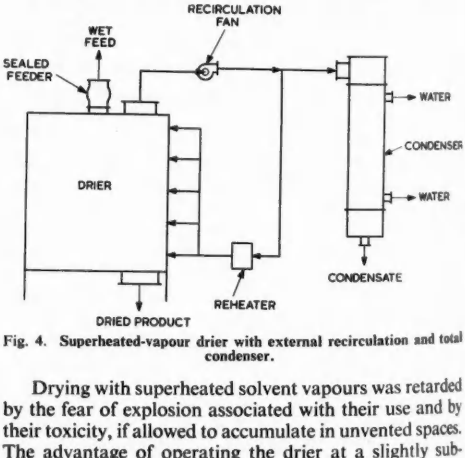

Fig. 4. Superheated-vapour drier with external recirculation and total condenser.

Drying with superheated solvent vapours was retarded by the fear of explosion associated with their use and by their toxicity, if allowed to accumulate in unvented spaces. The advantage of operating the drier at a slightly sub-atmospheric pressure (less than 0·01 in. H_2O), as is possible in the turbo-type drier, is therefore apparent.

For safe operation, provision must be made for purging the system of air during start-ups and shut-downs and for instrumentation which will indicate the accidental presence of an explosive mixture within the system or an excessive vapour concentration in the surrounding space.

(Concluded on page 232)

The Stability of Synchronous Generators during Fault Conditions

By T. LAIBLE. (From *Bulletin Oerlikon*, No. 310, 1955, pp. 37–44, 9 illustrations.)

THE problem of dynamic stability arises when several power stations operate in parallel. This refers particularly to the question whether it is possible to continue parallel operation after the occurrence of a disturbance without the need for resynchronizing. The disturbance can be caused by a short-circuit on the interlinking transmission line or by sudden large load changes. This upsets the balance between the electrical output from the coupled generators in the power station and the power output from the turbines. The surplus energy will accelerate the alternator rotors, thus causing some to lead over others. Should this disturbance last too long, the difference between the rotor angles may become too great, and the sets will be out of step. Stability examinations, therefore, consist mainly in determining the torque produced by the alternator during a system disturbance and from this to evaluate the relative rotor movement. In order to make these conditions quite clear, a simplified example is investigated, as shown in Fig. 1, assuming a single power station feeding a large consumer network *N* over several parallel feeders, the location of the fault being at *F*.

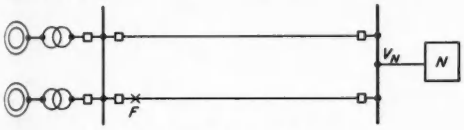

Fig. 1. Diagram of power system discussed.

System disturbances can be produced by several kinds of short-circuits on one of the parallel feeders. Of particular interest are those faults which occur near the station bus-bars, since these are the most dangerous to stability. The simplest and most common fault is the single-phase earth fault. Unless the neutral point is earthed, this fault would produce no disturbance. However, systems which have to transmit large amounts of power are nowadays frequently constructed with solidly earthed neutrals, thus permitting considerable economy to be made in station insulation. A more severe fault is a short-circuit between two phases; however, this is more rare than the short-circuit between two phases associated with an earth fault and commonly called a "double earth fault". The most severe fault is the three-phase short-circuit; while it persists power transmission is completely interrupted. Fortunately, it occurs very much less frequently than the other faults mentioned, and the stability of the system is generally regarded as satisfactory if parallel working can be maintained under these less onerous conditions.

During fault conditions several distinct periods can be observed, during which system behaviour varies. The first period is that during which the fault persists until the relay operating time and the tripping time of the circuit-breaker have expired and the affected line is disconnected. In the subsequent period the power station is connected to the distribution system only by the remaining transmission lines. If originally more than two such lines were in use, it is quite likely that stable operating conditions would be re-established. In many cases, however, this will not apply, and the affected line has to be reconnected as soon as possible. By interrupting all three phases the arc caused by the fault will be quickly extinguished (unless a permanent metallic path has been formed). The time after which the breaker can be reclosed will then depend upon the de-ionizing time of the arc path and will not exceed 0·25 sec. If a single-pole earth fault occurs and only the affected phase is disconnected, the fault-arc can be supplied by currents drawn from the two unaffected phases due to capacitive coupling. The higher the system voltage and the longer the transmission line the longer will the arc persist. The interval after which re-closure is permissible is therefore correspondingly longer (0·5 sec or even more). This, however, does not affect system stability, because the coupling between power station and distribution network is maintained over the two non-affected phases and is, in fact, even strengthened.

SIMPLIFIED DIAGRAMS

By applying the theory of symmetrical components[1, 2] it is possible to construct a simplified diagram for each fault condition. This diagram can then be used to determine the torque of the generator rotors. Fig. 2 shows the simplified diagram appertaining to the conditions existing when a short-circuit across two phases on one of the two parallel lines occurs. In this case the fault current in one phase is zero whilst the two others are short-circuited; the simplified diagram then consists of the series connection of the positive and negative phase-sequence systems, when viewed from the fault position. This case is illustrated in Fig. 2a, in which the positive-

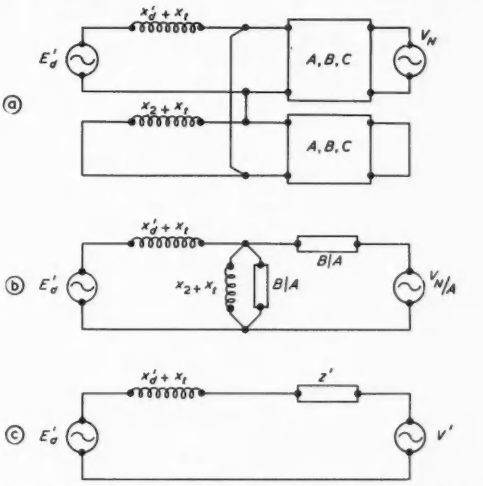

Fig. 2. Development of a simplified diagram for a double-pole short-circuit.

sequence system is shown in the upper part of the diagram, and the negative-sequence system in the lower part. The two parallel lines are shown as a four-terminal system with the constants *A*, *B*, and *C*, so that this simplified diagram can be applied to any length of transmission line. The generating station is represented by the transient e.m.f. E'_d in series with the generator transient reactance x'_d and the transformer short-circuit reactance x_t. In the negative phase-sequence system there are no electromotive forces, and the transient reactance has to

be replaced by the inverse reactance x_2. The e.m.f. E'_d corresponds with the rotor flux produced by the excitation winding at the commencement of the fault. Owing to the large time-constant of the field system, this flux and therefore also E'_d will remain practically constant for at least a few tenths of a second.

It is possible further to reduce diagram Fig. 2a, since the only present consideration is the behaviour of the complete system when viewed from the generating station ; the four-terminal network can then be replaced by its short-circuit impedance B/A and its no-load voltage V_N/A, when viewed from the input end. The diagram so obtained and shown in Fig. 2b can then be reduced still further in the same manner by replacing the complete network to the right of the generating station by its short-circuit impedance z' and its no-load voltage V'. Fig. 2c now shows the generator feeding a system at voltage V' through the series reactance x_e, where

$$x_e = x_t + Im(z') \approx x_t + |z'| \quad \ldots \ldots (1)$$

The rotor torque has, therefore, to be determined[3,4,5,6] with these reactance and voltage values. Similar diagrams can be developed for other fault conditions and also for the conditions existing after disconnection of the faulty transmission line. These diagrams differ from each other only by the values of x_e and V'.

Equation of Rotor Motion

After a fault has occurred the rotor torque M always becomes less than the normal torque. Turbine torque M_o, however, remains constant until the action of the governor becomes effective ; this may take up to 2 sec, and this effect can, therefore, be neglected. This surplus driving torque accelerates the rotor, and angle δ increases. The acceleration can be expressed by the following equation :

$$\frac{H}{\pi f_n} \frac{d^2\delta}{dt^2} + M = M_o \quad \ldots \quad \ldots (2)$$

where H is the inertia constant[3] and f_n the rated frequency [cps] ; M and M_o are referred to the rated torque corresponding to the kVA rating of the machine.

Turbine torque is, strictly speaking, not constant, but varies slightly with speed. It is reduced when the speed rises and therefore provides a small contribution, acting in the same direction as the damping torque ; for this reason it is added to the latter. The additional damping value will lie between 1·2 and 0·5 for water turbines, the highest value referring to turbines of low specific speed (Pelton wheels, slow-running Francis turbines), and the lowest to those of high specific speed (Kaplan and propeller turbines and fast-running Francis turbines[7]). Steam turbines will provide a similar contribution, the value of which will lie around unity.

Sequence of Events Caused by the Disturbance

As an example, consider the sequence of events caused by a double earth fault. The affected transmission line is assumed to be disconnected on all three phases after 0·15 sec and reconnected after an interval of 0·3 sec. The collapse of the voltage due to the occurrence of the fault causes the impulse excitation relay to operate and to produce maximum exciter field. E'_d, therefore, does not remain constant but is slightly increased. Fig. 3 illustrates the movement of vector E'_d in relation to the fixed network voltage vector V_N. In the left-hand example the power delivered into the network immediately prior to the fault was 297 MW ; in the right-hand example 314 MW, this latter value lying just beyond the stability limit, which is exactly 310 MW. In both cases the total time t_1 for isolation of the faulty line was 0·15 sec, and the total time t_2 elapsing before reconnection was 0·45 sec, so that $t_2 - t_1 = 0{\cdot}3$ sec, as mentioned above.

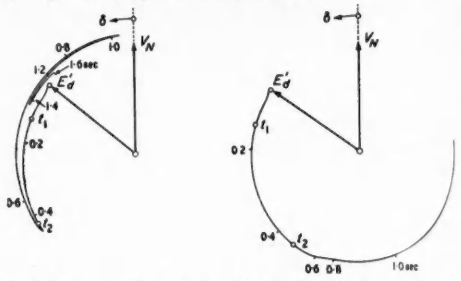

Fig. 3. Diagrams illustrating the stability of a double transmission line, 156 miles long, with a system voltage of 220 kV, when subjected to a double-pole earth fault near the power station.

The movement of E'_d also represents the rotor movement. It is, therefore, possible to extract the angle δ and its variation with time, i.e., the slip s, from Fig. 3, and to draw a graph showing its relation to time. Of still greater interest, however, when examining stability conditions, is the diagram showing the relationship between δ and slip (Fig. 4), which contains curves showing rotor movement during a double-pole earth fault and stability limits, representing particular solutions of the rotor-motion equation relating to the conditions after reconnection. Apart from point δ_o which corresponds with stable operation before the fault occurred, there exists also a second, larger value δ_s of the rotor angle for which $M = M_o$, i.e., in which the two values are balanced. At point δ_o conditions are stable, at δ_s they are not. The

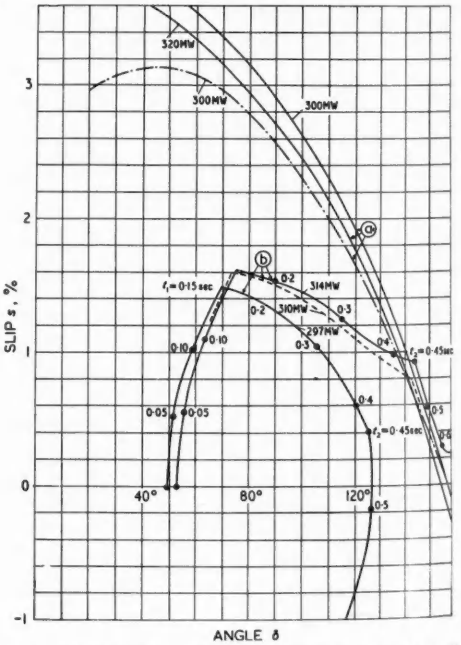

Fig. 4. Limits of stability (curves a) and rotor movement (curves b) during a double-pole earth fault.

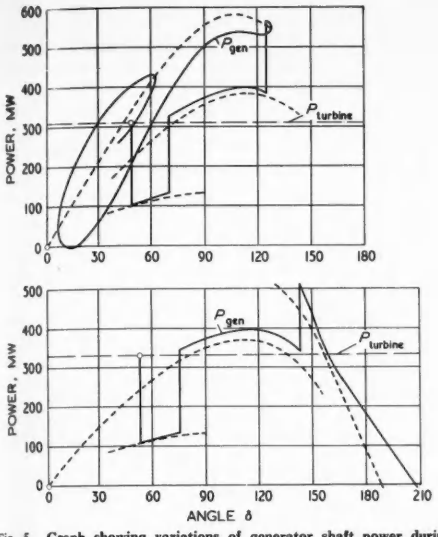

Fig. 5. **Graph showing variations of generator shaft power during fault conditions.**
Full curves : Total electrical power.
Dotted curves : Synchronous power.

stability limit represents a particular solution of the equation of motion for the final conditions, passing through point δ_s. Since δ_s depends to some extent on M_o, a limiting curve can be drawn for every amount of power transmitted. A movement which commences towards the right-hand side of the limiting curve, as for example, that relating to the reconnecting of the line when it was carrying 314 MW, can never lead back to stable point δ_o. It is, therefore, sufficient to examine the rotor movement during the first two periods of the disturbance in order to establish positively whether or not stable operating conditions are possible. Fig. 4 shows particularly clearly the influence of the switching times, especially the important role of the tripping time in relation to the magnitude of the stable power which can be transmitted. A reduction of this time by only 0·01 sec will increase the transmitted power by 10 MW. A reduction of the interval between disconnection and reconnection is also beneficial, though far less effective. Fig. 4 also shows (in chain-dotted lines) the stability limit for 300 MW for a machine without damper windings, thus illustrating the influence of damping torque. In the case investigated, the limiting value was reduced from 310 MW to approximately 290 MW, i.e., by 7%.

Power, Voltage, and Current during Fault Conditions

The power available at the turbine shaft is indicated in Fig. 5. The dotted curve shows the contribution made by synchronous torque ; the difference between the dotted curves and the solid curves represents the contribution of damping torque M_d. It is clearly noticeable that, particularly for the period from disconnection to reconnection, the damping torque provides an important contribution. A measure of this is the ratio of the area between the dotted and full curves to that between the dotted curve and the horizontal base line which represents the turbine output.

Fig. 6 illustrates the variations of terminal voltage and current of the generators. For the period during which

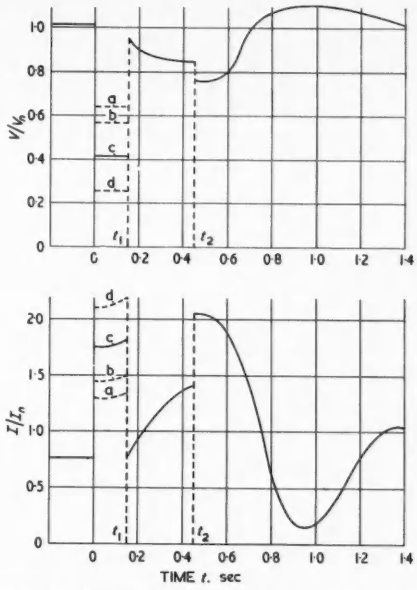

Fig. 6. **Generator terminal voltage and current during fault conditions.**
(a) Single-pole earth fault.
(b) Short-circuit across two phases.
(c) Double-pole earth fault.
(d) Short-circuit across three phases.

the fault persists, the values have been shown for different types of faults ; the subsequent variation, however, has been indicated only for the case of the double earth-fault. The illustration shows that the terminal voltage in each case drops sufficiently to cause operation of an impulse excitation relay, if fitted. After disconnection of the faulty line it soon recovers to approximately its normal value, and impulse excitation ceases.

Influence of Excitation

The variations of the exciter voltage V_f with time are shown in the graph in Fig. 7, as well as that of E'_d resulting from it. V_f is the voltage at the rotor slip-rings and is identical with the main exciter armature voltage. The latter is referred to V_{fn}, the generator voltage under rated working conditions. After operation of the impulse excitation relay, its variation will depend only on the characteristic of the exciter, i.e., on its time-constant T_{eo} and maximum voltage ratio $V_{f\,max}/V_{fn}$. For comparison, Fig. 7 also shows the curves of E'_d and V_f which would have been obtained with a normal, not over-dimensioned exciter (curves b) and also of E'_d with fixed excitation of the main exciter, i.e., without control. It can be clearly seen that, during the period most important for maintaining stability, E'_d is increased by impulse excitation by about 10% ; with a normal exciter it remains about constant and without control, i.e., with fixed excitation, it decreases by about 5%. Keeping E'_d constant in this example would result in the lowering of the stability limit from the 310 MW obtained with impulse excitation to about 295 MW.

Possible Means of Improving Stability

Having obtained some insight into the behaviour of the machine during fault conditions, it is desirable to survey briefly means of improving dynamic stability.

One effective method would be the switching-in of loading resistances to counteract the loss of transmission capacity ; with the larger powers concerned, however, this method would be uneconomical and is but rarely employed. Also very effective is the reduction of the switching time,[8] but there are limits below which this cannot be reduced, because of other functions to be performed by the high-tension breakers.

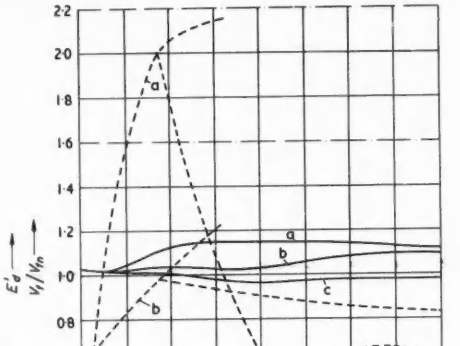

Fig. 7. Exciter and rotor flux.
(a) Impulse excitation with specially designed exciter (excitation speed 3·5).
(b) Automatic regulator with orthodox exciter (excitation speed 0·85).
(c) Uncontrolled.

All other methods employed aim at increasing synchronous torque. A reduction of the reactances is beneficial to all torque components, i.e., synchronous torque and damping torque. It is possible, by skilful design, to reduce the generator reactances slightly ; if greater reductions are required, it would become necessary to over-dimension the machine. Whether the consequent increase in cost and weight is economically justifiable can only be decided for each particular case.[8,9] Over-dimensioning the machine will also increase the moment of rotor inertia, and this too is of advantage, as it will cause the slip to increase more slowly during fault conditions. The external reactance can also be reduced ; the most effective but also most expensive method of doing this is the employment of a larger number of parallel transmission lines. A more economical way of achieving similar, but not quite so effective, results is the use of bunched conductors and series condensers. The latter will require short-circuiting during fault conditions in order to avoid damage and are then ineffective at these moments. They do, however, increase the coupling torque between the generating station and the network after re-connection ; the limiting curves in Fig. 4 are moved over to the right and the initial angle δ_o for the same power is reduced.

Effective, but comparatively costly, would be a continuous increase of E'_d by compensating the capacitive wattless line current by choke coils ; this will call for an increased excitation of the generators during normal working.

The beneficial influence of damper windings is undeniable. Though the gain is small, the costs are which this is obtained are low, compared with the overall costs. Damper windings are also useful for other reasons which have no connection with stability problems.

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The Application of Superheated-Vapour Atmospheres to Drying

(Concluded from page 228)

Future Investigations

Comparatively little investigation has been carried out on the drying of solids with superheated vapours, especially in the falling-rate period. It is expected that the drying time in the falling period will be considerably shortened in superheated-vapour operation because of the higher temperature level maintained in the solid. This would be highly important for those products which have a long drying time in the falling-rate period.

Investigations are needed into the physical changes occurring during superheated-vapour drying, as compared with air drying. At increased drying rates, the bulk density of some products may become lower. Other physical properties of the superheated-vapour-dried product may also be radically different from those of an air-dried product.

The question of the equilibrium moisture content of a superheated-vapour-dried product requires considerable study before general conclusions can be drawn. There is some question as to whether there can be an equilibrium moisture content with superheated vapour. It is known that the void spaces of a dried product are filled with the superheated vapour, which should be regarded as residual moisture. This residual moisture cannot be removed by superheated-vapour drying. Controlled purging with air is mandatory in the case of inflammable vapours. Purging is also necessary in any case where low moisture contents are desired.

The possibility of drying with superheated vapours, although not new, is only now reaching commercial feasibility. Its practicability has been demonstrated, and commercial equipment is available. Engineering and design-improvement programmes are actively being pursued to provide better superheated-vapour drying equipment and auxiliaries at lower cost.

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Torque Irregularities in Flexible Couplings

By B. KOZINA. (From *Acta Technica, Univerza v Ljubljani Tehniska Fakulteta*, Series Machinarum 2, No. 4, December 1955, 25 pages, 7 illustrations.)

HIGHLY flexible couplings with rubber or steel-spring elements, besides transmitting the normal driving torque, are able to cope with angular displacements of up to ± 20 deg., owing to the instantaneous phase differences between driving and driven machines. As examples of such couplings may be mentioned the " rubber-tyre " type of coupling with a peripherally clamped strip of rubber forming the flexible connection between the two coupling members, and the "omega-spring " coupling with Ω-shaped springs fitted in slots in the peripheries of the coupling members.

The purpose of this paper is to show that the effect of a flexible coupling is dynamically equivalent to that of a flywheel in smoothing out torque irregularities at certain positions of a system ; it also shows how a coupling responds to periodic and non-periodic torques and shock loads, and indicates a procedure for calculating the optimum stiffness of a coupling for the particular conditions under which it is to be employed. The fields of application of flexible couplings, however, are not identical with those of flywheel masses, and it is therefore necessary to define the limitations for each of these components.

TYPES OF TORQUE FLUCTUATIONS

Broadly speaking, it is possible to distinguish between three types of torque fluctuations, i.e., (1) cyclic or alternating torques, with constant peak values for their sinusoidal harmonic components ; (2) torque variations due to rapid load changes occurring at irregular intervals ; and (3) shock-load torques due to impact-type contact of two masses in the system.

For cyclically varying torques the mathematical expression is

$$T(\omega t) = \tfrac{1}{2}T_0 + \Sigma T_n \sin(n\omega t + \varphi_n)$$

where T_0 = mean transmitted torque, T_n = harmonic torque at a phase velocity $n\omega$, t = time, and φ_n = phase angle relative to time $t = 0$.

For load-change torques, assuming a rectangular pulse variation, if $0 < t_1, T = 0$; if $t_1 \leqq t \leqq t_2, T = T_p$; and if $t_2 < t, T = 0$.

For impact torques, consider the impact of an inertia J_s with a kinetic energy W_s acting on another inertia J. Because the materials in contact have some elasticity, it can be assumed that the impact torque rises sinusoidally from $T = 0$ up to a maximum shock value T_s, so that, if $t_1 \leqq t \leqq t_2$,

$$T = T_s \sin \omega_s (t - t_1).$$

Furthermore, $\omega^2 = k_s[(1/J_s) + (1/J)]$, where ω_s = vibration velocity of the sub-system, consisting of the inertia masses J_s and J and the stiffness k_s at the impact position. The pulse duration is $\tau_s = \pi/\omega_s$. The peak torque T_s of the impact is obtainable from

$$T_s = \tfrac{1}{2} W_s \frac{\omega_s}{\omega_0}$$

where ω_0 = angular velocity of normal (shaft) rotation. Thus, the less " spring " there is at the position of impact, the higher will be the value of T_s, while the pulse duration τ_s will be correspondingly shorter. If J consists of two masses J_1 and J_2, which are close-coupled, $J = J_1 + J_2$ should be used, and T_s is increased correspondingly. If these masses are flexibly coupled, $J = J_1$; hence, the impact torque is lower in this case.

METHODS OF REDUCING TORQUE FLUCTUATIONS

The Governors of large driving aggregates cope only with large changes of load of appreciable duration ; they do not respond to short-time torque fluctuations, which would make them unstable. Therefore, they are not considered in the following, nor are other arrangements, particularly of engines and compressor units, which are combined in such a way as to counteract their irregularities and hence the fluctuations of their combined output torque.

The principal means of reducing fluctuations are provided by flywheels and highly flexible couplings. It is not always suitable to increase the flywheel size, since this represents increased weight and costs, and also makes starting conditions more difficult. Flexible couplings may offer a more acceptable solution.

Clutches and hydraulic and electromagnetic couplings are also capable of dealing with large torsional deflections and are " flexible " within limits ; their slipping action also has a vibration-damping effect. Belts react to pulsating loads in the same way as flexible couplings. It is not usually easy to decide on the best combination for a particular application.

The concept of the irregularity factor is not usually clearly presented, but is only defined as the irregularity due to angular velocity fluctuations, i.e.,

$$C_v = 2(\omega_2 - \omega_1)/(\omega_2 + \omega_1)$$

where ω_2 and ω_1 are the maximum and minimum values of angular velocity, while $\frac{1}{2}(\omega_1 + \omega_2)$ is its mean value. Published literature indicates that the irregularity C_v should not be greater than, say, 1/300 for a.c. generators, 1/100 for textile spinning machines, 1/80 for machine tools, and 1/20 for pumps, compressors, etc.

The question is whether the above definition of irregularity is suitable. Considering spinning machines, for instance, it can be seen that the important irregularity factor is that of tension, i.e., of angular acceleration. For alternators also, the speed variation represents what is really a change in rotor torque, i.e., a change in load. Therefore, it is more suitable to regard the irregularity

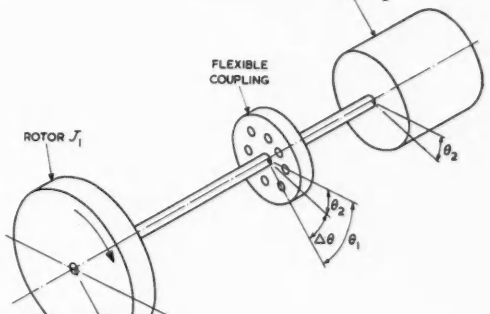

Fig. 1. System with two exibly coupled rotors.

of a machine as an irregularity in acceleration or in load torque. As the two rotors of a system generally have different inertias J_1 and J_2, when a flexible coupling is used, their " torque irregularities " will also differ. These can be defined as

$$C_{T_1} = T_1/T_0 \text{ and } C_{T_2} = T_2/T_0$$

where $T_{1,2}$ = torques on $J_{1,2}$, and T_0 = transmission torque. There are no indications in the literature of numerical values for permissible torque irregularities, such as are defined above. It is thus necessary to obtain data on permissible torque variations for the two main classes of machines, i.e., prime movers and driven machines. Preferably, these values should be based on each machine considered by itself, so as to obtain " characteristic " C_T-values ; these could then be used for determining the stiffness (or flexibility) and the inertia of the required coupling and flywheel masses.

Torsional Vibrations of Two Flexibly Coupled Rotors

Considering the system shown in Fig. 1, constant torque T_0 is transmitted from one rotor J_1 to the other J_2, without causing any irregularity in rotary motion. However, if a variable torque T acts on rotor J_1, it will cause the latter to deflect through an angle θ_1, and the second rotor will move through an angle θ_2. The coupling deflection, therefore, is $\Delta\theta = \theta_1 - \theta_2$. For simplicity, suppose the coupling to have a constant stiffness k. It will then transmit to the rotor J_2 an additional pulsating torque

$$T_2 = k\Delta\theta,$$

where $k = T_0/\Delta\theta_0$, $\Delta\theta_0$ being the twist due to the steady torque T_0. The fraction T_1 of the pulsating torque T which is not transmitted to J_2 will accelerate J_1 ; therefore, $T_1 = T - T_2 = J_1\theta_1''$, where $\theta'' = d^2\theta/dt^2$. The equations of motion of the two-mass system, with damping neglected, can now be considered.

(1) *Periodically Varying Torque* :—

Let $T = T_n \sin n\omega t$. The governing equations are then

$$J_1\theta_1'' = T - T_2 = T_n \sin n\omega t - k\Delta\theta$$

and $J_2\theta_2'' = +k\Delta\theta$

where $n\omega$ = phase velocity and T_n = peak value of the torque T. Solving for $\Delta\theta$, with $\omega_n^2 = k[(1/J_1) + (1/J_2)]$ and $\theta_1 = \theta_{01} \sin n\omega t$, etc.,

$$\Delta\theta = (T_n/A) \sin n\omega t \times M_n$$

where $A = k[1 + (J_1/J_2)]$ and $M_n = 1 - (n\omega/\omega_n)^2$.

As the stiffness k of the coupling is a low value, the phase velocity ω_n of the free vibration is also low, and the " resonance factor " M_n can be maintained at less than unity. For a fully rigid connection, $M_n = 1$ (since then $\omega_n^2 = \infty$).

In order to determine the irregularity factors of individual machines, it is also necessary to know the inertia torques of each rotor ; these are

$$T_1 = J_1\theta_1'' = T_n \sin n\omega t - k\Delta\theta$$
$$= [1 - (M_n k/A)] \times T_n \sin n\omega t$$

and $T_2 = T_n - T_1 = (M_n k/A) \times T_n \sin n\omega t$.

For a rigid connection, $M_n = 1$, as previously stated, and the distribution of the torques depends only on the ratio of the rotor inertias. With a flexible connection, M_n can be much smaller than unity, and the torque on J_2 is then correspondingly reduced.

However, the reduction of the acceleration of the second rotor is possible only by a corresponding increase in the acceleration of the first rotor (Fig. 2). The flexible coupling therefore alters the torque distribution. If the torques transmitted to J_2 with a flexible and a rigid connection are $T_{2\text{flex}}$ and $T_{2\text{rigid}}$ respectively, then $T_{2\text{rigid}} = J_2\theta_2'' = J_2 \times T_n/(J_1 + J_2)$, since in this case $\theta_2'' = \theta_1'' = T_n/(J_1 + J_2)$. As $T_{2\text{ flex}} = T_n M_n/[1 + (J_1/J_2)]$ from the above results, the torque transmission ratio R of the vibratory torques is obtained as $R = M_n$.

To obtain R-values of 0·1 or even less, it is desirable, therefore, to have a resonant phase velocity ω_n for the coupling and the rotor inertias which will be well below the lower speed limit of the driven system. Then, even if the resonance zone is traversed during starting or stalling, the transient will not have time to build up to any appreciable amplitude.

For simplicity, the effect of damping has been neglected. If it is taken into account by means of the non-dimensional ratio $\gamma = c\omega_n/(2k)$, where $c = T/(\Delta\theta)$ is the damping coefficient of the coupling, the resonance factor becomes

$$M_n = \sqrt{1 + 4\gamma^2} \Big/ \sqrt{[1 - (n\omega/\omega_n)^2]^2 + 4\gamma^2}.$$

For steel-spring types of couplings, γ is nearly equal to zero ; for rubber couplings $\gamma = 0{\cdot}12$ to $0{\cdot}16$. If $n\omega/\omega_n \geq 3$ (i.e., if the lowest running speed is more than three times higher than the resonant frequency of the coupling system), this being the favourable condition to be attained, the effect of γ on M_n is negligible ; consequently, γ will not affect the torque transmission ratio R.

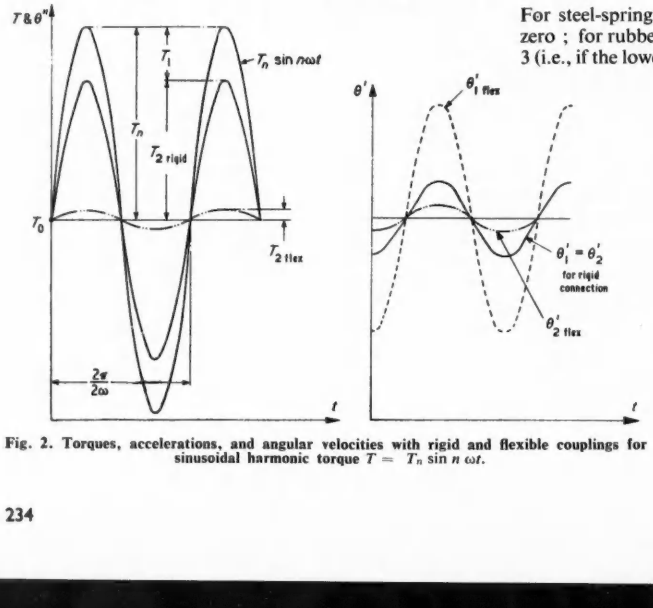

Fig. 2. Torques, accelerations, and angular velocities with rigid and flexible couplings for sinusoidal harmonic torque $T = T_n \sin n\omega t$.

(2) *Load-Change Torques* :—

These are non-periodic changes. The governing equations are similar to those previously considered :

$$J_1\theta_1'' = T_p + k\Delta\theta$$
$$J_2\theta_2'' = -k\Delta\theta$$

From these, $\Delta\theta'' + k\Delta\theta \times [(1/J_1) + (1/J_2)] = T_p/J_1$

or, with $\omega_n^2 = k[(1/J_1) + (1/J_2)]$

$$\Delta\theta'' + \omega_n^2\Delta\theta = T_p/J_1.$$

T_p is the additional torque exerted during the changed load condition for a period of time t. The solution of this differential equation, i.e., $\Delta\theta = T_p\,(1 - \cos\omega_n t)/(J_1\omega_n^2)$, determines the amplitude of the free vibration. To obtain the accelerating torques of the rotors, this expression can be substituted in the governing equations ; the results are

$$T_1 = J_1\theta_1'' = T_p + T_p\,(1 - \cos\omega_n t)/(1 + J_1/J_2)$$
$$T_2 = J_2\theta_2'' = T_p\,(1 - \cos\omega_n t)/(1 + J_1/J_2).$$

With a rigid coupling, the accelerating torque transmitted to J_2 is

$$T_{2\,\text{rigid}} = T_p/[1 + (J_1/J_2)]$$

Therefore, the load-impact transmission ratio is

$$R = T_{2\,\text{flex}}/T_{2\,\text{rigid}} = 1 - \cos\omega_n t.$$

R can be smaller than unity if the pulse duration t is less than $(\pi/2)/\omega_n$. This again means that ω_n should be a low value, to allow for comparatively large values of t.

The types of flexible couplings at present commercially available will usually reduce impacts of less than 0·01 sec duration. However, load changes of machines frequently extend over longer periods, so that it can be stated that these flexible couplings do not reduce the effects of protracted intermittent load variations. Even more highly flexible couplings are needed for this purpose, and considerable development work is being carried out in this direction.

If $\omega_n t$ is greater than $\pi/2$, R becomes greater than unity, with a maximum value $M_{s\,\max} = 2$. The flexible coupling transmits in this case twice as much torque as the rigid coupling and the rotors vibrate violently in antiphase. This apparent advantage of the rigid coupling cannot occur, however, since the shafting between two rotors is always flexible, so that torsional vibrations cannot be avoided at each change of load. The flexible coupling is, in fact, preferable, because with its very low frequency of natural vibration the number of torque reversals is considerably decreased and this also reduces the fatigue loading of rotor shafts, etc., between which it is interposed.

The effect of a flexible coupling is illustrated in Fig. 3, for the case of a rectangular torque pulse T_p acting on J_1. It is assumed that $J_2 > J_1$. With a rigid coupling, the greater portion of T_p is exerted on J_2, both rotors having the same acceleration. With a highly flexible coupling, J_2 receives initially only a very small accelerating torque (chain-dotted curve in Fig. 3) ; the acceleration θ_2'' becomes equal to that obtained with a rigid coupling, only if the pulse duration is fairly long, at $t = t_1 + (\pi/2\omega_n)$ and reaches its peak value at $t = t_1 + (\pi/\omega_n)$, which is twice the value occurring with a rigid coupling. It then falls off very rapidly.

Fig. 3 also shows the curves of the angular velocities θ_1' and θ_2' of the two rotors. With a rigid coupling, the velocity θ' of both rotors decreases uniformly during the loading period. With a flexible coupling, the decrease of θ_2' (chain-dotted curve) is less rapid initially and then more rapid after $t = \pi/\omega_n$, whereas the reverse takes place for θ_1'. Thus, the rotors (without damping) vibrate in antiphase, and as a result the system performs torsional vibrations when restored to normal load. The amplitudes of these vibrations depend on the time at which the additional load is discontinued and on any previous vibrations of the system. Therefore, it can be seen that, with $J_2 > J_1$, the flexible coupling reduces the torque transmitted to the second rotor.

(3) *Shock Loads or True Impact Torques* :—

The impact torque is $T = T_s \sin\omega_s(t - t_0)$. It is also reduced at the second rotor by means of the flexible coupling. Usually, the phase velocity ω_s at the impact position is much greater than ω_n, so that even less torque reaches J_2 than in the case of intermittent load changes. Consequently, the torque transmission ratio R_s will also be somewhat lower ; for a conservative assessment, therefore,

$$R_s = R_p = 1 - \cos\omega_n t.$$

It can thus be said that resilient couplings have a considerable effect in mitigating impact torques.

Optimum Stiffness of Couplings

From the above considerations, it follows that (1) the flexible coupling tends to resist the transmission of varying loads ; (2) it does not absorb fluctuations, but

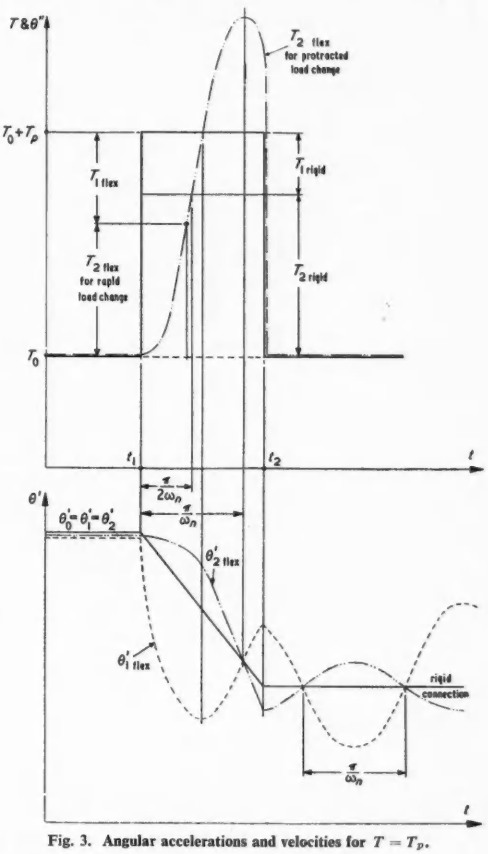

Fig. 3. **Angular accelerations and velocities for $T = T_p$.**

alters the distribution of torques (reduced torque on the second rotor results in a correspondingly increased torque on the first rotor) ; and (3) the flexible coupling makes it possible to couple together two machines which have different torque irregularities, without adding flywheel masses.

With regard to (2), it may be noted that the irregularity of rotor J_1 is $C_{T_1} = T_1/T_0$, whereas $C_{T_2} = T_2/T_0$,

(*Concluded on page 262*)

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A Sonic Technique for Testing Leather

(From *National Bureau of Standards Technical News Bulletin*, Vol. 40, No. 3, March 1956 pp. 35–37, 3 illustrations.)

In a recently developed non-destructive method of testing leather, based on the transmission of sound waves, the chief instrument employed is a pulse-propagation meter, which measures and records the speed of a generated sound pulse through the leather. As a result, the specimen under test is left unharmed, in contrast with the tearing or other destructive effects of existing test procedures.

Experiments have shown that the velocity of sound transmission in leather varies substantially with changes in chemical and physical structure and, particularly, in fibre orientation. Velocity measurements, accordingly, are indicative of modifications of the fibrous order produced by strain, ageing, and impregnating material.

In recent years the use of sonic techniques to determine certain mechanical properties of high polymers has become widespread. Such methods have employed frequencies ranging from less than 1 cps up to several megacycles per second. The use of a single frequency throughout a series of tests readily permits mathematical analysis of the data and determination of the physical constants characteristic of the visco-elastic behaviour of the material. Besides furnishing a means of securing fundamental information, sonic methods have been successfully utilized in non-destructive testing. These applications relate mainly to the location of flaws in a variety of manufactured products.

The investigations of the leather laboratory are part of a larger programme of fundamental and applied research on natural and synthetic polymers—rubber, plastics, textiles, leathers, and papers. This programme seeks not only to improve present basic knowledge of high polymers but also to make possible their more effective utilization in commercial products. The present study of the potentialities of sound-transmission measurements is expected to provide the basis for improved methods of testing finished products, as well as the unworked hide.

Sonic experiments by the NBS were based on the relationship between sound velocity and the elasticity of the medium, as given by Young's modulus. If a sound wave is propagated along a medium whose transverse dimensions are small, compared with the wavelengths utilized, then the following well-known relation holds :—

$$E = v^2\rho \qquad .. \qquad .. \qquad (1)$$

where v is the velocity of sound, ρ is the density of the medium, and E is Young's modulus. However, if the material produces appreciable acoustic attenuation, as shown by a notable decrease in the amplitude of the sound wave as it travels through the medium, the single relation given above no longer suffices for an accurate determination of the modulus. An additional factor based on a viscosity coefficient must then be applied to the right-hand side of the equation.

In the current investigation, estimates of sound attenuation in leather were obtained by observing on an oscilloscope the decreasing amplitude of a particular section of a 3000-cps wave train, as the transmitter and receiver crystals of the propagation meter were separated. On the basis of these rough measurements, the attenuation for shoe-upper leather was estimated at 0·1 to 0·2 neper/cm. For purposes of comparison, the attenuation constants were also obtained, under the same conditions of frequency and temperature, for other polymeric materials, with the following results :—Polyethylene, 0·12 neper/cm ; nylon (undrawn filament), 0·003 neper/cm ; and neoprene GN at 6% strain, 0·51 neper/cm.

It may be seen that the acoustic attenuation in leather lies midway between that of materials with highly crystalline fibres and that of rubber-like materials.

In developing leather test methods, attenuation and frequency are of secondary importance, because only relative velocity measurements are required to establish the deviation of a sample from its control. The data of this investigation were therefore studied in terms of the more directly measurable quantity, i.e., velocity. Now, the defining equation, E = stress/strain = load/elongation, makes clear the direct relation holding between E and the resistance to elongation. In the light of this relation, eq. (1) suggests that the speed of sound through a medium such as leather is greatest in the direction offering the greatest resistance to elongation, i.e., along the individual fibres.

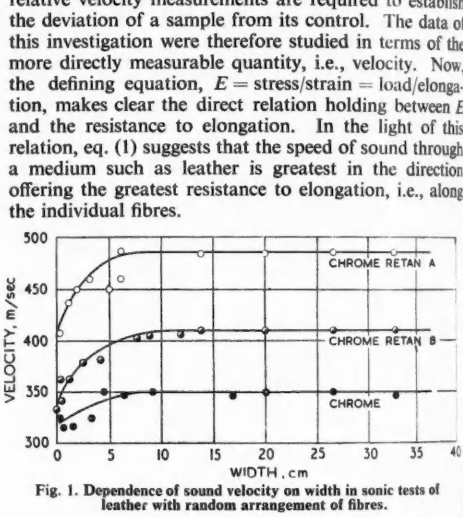

Fig. 1. Dependence of sound velocity on width in sonic tests of leather with random arrangement of fibres.

In experiments with leather from cattle-hide, the speed of propagation of sound varied with the lateral dimension of the specimen, increasing with width up to a certain maximum, dependent on the wavelength of the sound. In cattle-hide the fibres are oriented at random ; consequently, there is no sound path directly along the specimen. In this connection, Fig. 1 shows how sound velocity depends on width in sonic tests of leather with a random arrangement of fibres. The bottom curve relates to a specimen tanned with chrome only, while the two upper curves refer to specimens from different sources, tanned with chrome and retanned with vegetable tannins.

That the speed of sound through a material like leather is related to fibre orientation was shown with vegetable-tanned sharkskin. In sharkskin, the fibres occur naturally in a highly oriented basket-weave pattern, the two fibre axes being mutually perpendicular in the plane of the hide. Specimens were cut so that sound could be transmitted either in the direction of a fibre axis or at a 45-deg. angle with the axes. The specimens cut at an angle of 45 deg. with the fibre axes should have sound paths roughly comparable with those existing in cattle-hide, and velocity-width relations similar to those in Fig. 1 would be expected. On the other hand, specimens with one set of fibres oriented in the direction

(*Concluded on page 240*)

Technical Aspects of Levitation

By A. H. Boerdijk. (From *Philips Research Reports*, Vol. 11, No. 1, February 1956, pp. 45–56, 2 illustrations.)

There are numerous instances in which gravitational force is undesirable, and many attempts have been made to compensate this force in such cases. This article deals with that special type of compensation called levitation, in which a body is in a state of stable or indifferent equilibrium relative to the earth and in which material contact between the body and its environment is not essential.

In considering levitation, as the compensating forces must be independent of contact, it is necessary to exclude all kinds of forces which essentially have a short radius of action (of the order of the separation distances of atoms in solids, or less). Thus, as far as can be seen, two practical possibilities for the nature of the compensating forces remain, as follows :—

(*a*) *Reaction forces*, in which a jet of material is ejected from the levitated body in a vertically downward direction, the reaction on the body compensating the gravitational force acting on it.

(*b*) *Forces exerted by electromagnetic fields*, three cases of which are dealt with separately, i.e., a radiation field, a static or stationary field, and a quasi-stationary field.

A third method, i.e., the use of gravitational forces, in which an auxiliary body is located vertically above the body to be levitated, in such a way that the gravitational forces on the latter body balance, is, of course, quite impracticable, owing to the enormous mass of the auxiliary body which would have to be employed.

LEVITATION BY REACTION FORCES

Much has been published concerning these forces, which are often used in rockets and jet propulsion generally. For stationary rockets certain simple relations can be derived, from which the possibilities and limitations of this type of levitation are readily apparent.

If the levitated body has a mass $m(t)$, and per unit of time a small fraction ε of its mass is ejected with an initial velocity v vertically downwards, it follows from the impulse law (the relativistic correction taken into account) that, for compensation of the gravitational force $gm(t)$,

$$g = \frac{\varepsilon v}{\sqrt{1 - v^2/c^2}} \quad .. \quad .. \quad (1)$$

where c is the velocity of light, so that

$$\varepsilon = \frac{g}{v}\sqrt{1 - v^2/c^2} \quad .. \quad .. \quad (2)$$

The minimum power P needed per unit of mass of the body will be

$$P = \varepsilon c^2\left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right) = \frac{gc^2}{v}\left(1 - \sqrt{1 - v^2/c^2}\right) \quad .. \quad .. \quad (3)$$

a function of v only. This power may be supplied either from outside (it is assumed without any additional force) or from the levitated body itself. Denoting by T the interval of time in which the mass of the body will have diminished to half its initial value, then, in the case where the power is supplied from outside, $dm(t) = -\varepsilon m(t)dt$, so that

$$T_1 = \frac{v}{g}\frac{\log_e 2}{\sqrt{1 - v^2/c^2}} \quad .. \quad .. \quad (4)$$

In the second case, in which power is supplied from the levitated body itself, the mass of the body will decrease per unit of time, not only by the amount $\varepsilon m(t)$ of the ejected mass, but also by the equivalent mass of its energy, i.e., $Pm(t)/c^2$. Hence,

$$T_2 = \frac{v \log_e 2}{g} \quad .. \quad .. \quad .. \quad (5)$$

Eliminating v from eqs. (3), (4), and (5)

$$P_1 = gc\left(\sqrt{1 + k^2} - k\right) \quad .. \quad .. \quad (6)$$

$$P_2 = gc\left(k - \sqrt{k^2 - 1}\right) \quad .. \quad .. \quad (7)$$

where $k = (c/gT)\log_e 2$.

Fig. 1 shows the relation between P and T for the two cases. A v-scale has been added to the P-scale, using eq. (3). For values up to about $P = 10^9$ W/kg or $T = 10^7$ sec, the relationship is practically linear, and to a first approximation

$$P = \frac{g^2 T}{2 \log_e 2} \approx 69\,T, \text{ and } v = \frac{gT}{\log_e 2} \approx 14\,T \qquad (8, 9)$$

For the most suitable common propellant used up to now in rockets, v is about 3500 m/sec, and thus T will be about 250 sec (point *a* in Fig. 1).

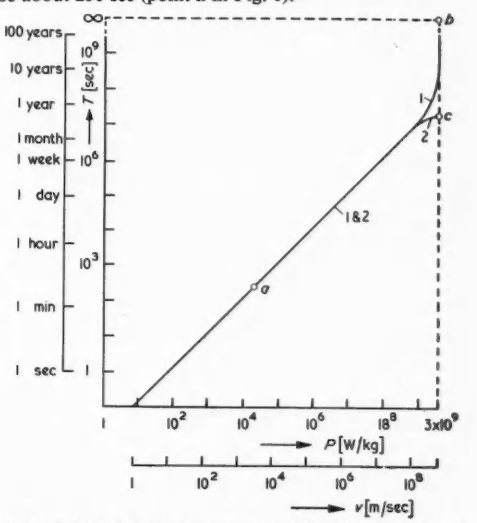

Fig. 1. Relation between the power required for levitating a body by reaction forces and the interval T in which the mass of the body will be halved.
(1) Power is supplied from outside.
(2) Power is supplied from the levitated body itself.

Stability of the position of the levitated body can be obtained by stabilizing methods commonly used for rockets.

If P approaches $gc \approx 3 \times 10^9$ W/kg, T approaches infinity (point *b* in Fig. 1) in the first case, and the value $c \log_e 2/g \approx 2{\cdot}12 \times 10^7$ sec ≈ 245 days in the second (point *c*). The latter is the upper limit of values of T obtainable for a completely independent body with this type of levitation.

FORCES EXERTED BY ELECTROMAGNETIC FIELDS

Levitation by Forces in a Radiation Field

Suppose the wavelength of the radiation to be small, compared with the horizontal dimensions of the body, the action on which can be described in terms of radiation pressure. Two cases must be distinguished. In the first case the body emits radiation, while in the second case it is situated in the radiation field of an external source. To make the radiation pressure as effective as possible, the direction of the radiation must be vertically downwards in the first case, and vertically upwards in the second.

Suppose that in the first case the emitted radiation bundle has an effective horizontal cross-section of area s, the power per unit area in that cross-section being p. The radiation pressure must compensate the gravitational force mg on the body. Hence,

$$mg = ps/c \qquad .. \qquad .. \qquad (10)$$

For the radiation power per unit of mass of the body, from eq. (10),

$$P_1 = ps/m = gc \qquad .. \qquad .. \qquad (11)$$

This is exactly the same value as in the cases dealing with reaction forces, represented by points b and c in Fig. 1. These points do, in fact, represent levitation by radiation pressure. For $P = gc$, eqs. (2) and (3) lead to $\varepsilon = 0$ and $v = c$. This means that no mass as such is ejected, but energy with velocity c only, i.e., photons and radiation.

The interval of time in which the weight of the body will be halved can be found from eq. (5) by substitution of $v = c$, and is equal to $c \log_e 2/g \approx 2{\cdot}12 \times 10^7$ sec $\approx$ 245 days, as at point c in Fig. 1.

In the second case the radiation will generally be partly absorbed and partly reflected by the body. To obtain the largest possible compensating force there must be complete reflection. For the radiation power per unit mass of the body,

$$P_2 = gc/2 \qquad .. \qquad .. \qquad (12)$$

If, starting from the preceding case, the wavelength is increased, the direction of the radiation emitted or reflected by the body can no longer be substantially vertical, owing to the decreased directivity of the emitter or to scatter. This effect tends to decrease the mean vertical component of the impulse of the photons emitted or reflected by the body. By applying the impulse law it is found that eqs. (11) and (12) represent the lower limits for the power per unit mass.

By introducing repeated reflections, each of the photons of the radiation bundle may be used a number of times for transfer of impulse to the body. In this way the net power per unit mass could be made much smaller than indicated by eqs. (11) and (12). However, losses by absorption and scattering are unavoidable. Since the power indicated by these equations is of the order of 10^9 W/kg, the net power will still be enormous, even if the relative losses are extremely small, e.g., 10^{-3}. Thus, realization seems next to impossible.

Static and Stationary Fields

Levitation by means of magnetostatic or electrostatic fields would appear to be very advantageous, inasmuch as no power would be necessary. Several suggestions have been made for obtaining levitation by means of mutually repelling permanent magnets but, in cases where success has been reported, at least one of the degrees of freedom of movement of the body has been eliminated by some mechanical constraint, depending essentially on contact of the body with its environment. The basic theorem, stating the instability of a static system consisting of particles which either repel or attract one another with forces varying inversely with the square of their distance, was formulated and proved by Earnshaw in 1842. Earnshaw's theorem was applied to the electrostatic field by Maxwell in 1873, and to the magnetostatic field by Tonks in 1940. The most complete theory was given by Braunbek[1] in 1939, who proved that levitation in electrostatic, magnetostatic, and stationary electromagnetic fields is impossible, because of instability, if the relative dielectric constant ε_r and the relative permeability μ_r are $\geqslant 1$ everywhere in the system. Since $\varepsilon_r \geqslant 1$ for all materials in all circumstances, it follows that levitation is impossible in an electrostatic field, whereas it is at least not impossible if the field is magnetic, and materials with $\mu_r < 1$ are present.

There are two classes of such materials, i.e., diamagnetic materials, for which μ_r is slightly less than unity, and materials in the superconductive state, which can be said to behave as if $\mu_r = 0$. As the superconductive state exists only if the magnetic field does not exceed a critical value which is a function of the temperature, the use of the latter class is restricted. Moreover, the necessity of maintaining a sufficiently low temperature is troublesome.

In general, the body as well as its environment may contain sources of the magnetic field and the diamagnetic or superconductive material. Three cases are considered, as follows :—

Levitation of diamagnetics or superconductors in static or stationary magnetic fields :—Consider a magnetic field *in vacuo* acting on a small volume element dV of a diamagnetic substance. Denoting by z the coordinate measured in the vertical direction, increasing upwards, the force df exerted in this direction by the field will be, to a first approximation[2],

$$df = -\tfrac{1}{2}\mu_0 (1 - \mu_r) \frac{\partial H^2}{\partial z} dV, \qquad .. \qquad .. \qquad (13)$$

in which μ_0 is the absolute permeability of empty space. For levitation, at least the gravitational force $gdm = \rho g\, dV$ has to be compensated, so that

$$\frac{\partial H^2}{\partial z} \geqslant -\frac{2g}{\mu_0} \frac{\rho}{1 - \mu_r} \qquad .. \qquad .. \qquad (14)$$

For practically all known diamagnetic materials $\rho/(1 - \mu_r)$ is very large. Relatively small values, of the order of 2×10^6 kg/m^3, occur in a number of organic substances such as $Hg(CH_3)_2$ and $Hg(C_2H_5)_2$. Application of these substances is not attractive, because they are liquid at room temperatures and moreover very poisonous. Next in the range are graphite and bismuth, for which $\rho/(1 - \mu_r)$ equals $2{\cdot}3 \times 10^7$ and $6{\cdot}1 \times 10^7$ kg/m^3 respectively. These values are approximate, because μ_r depends on the direction of the magnetic field relative to the crystal axes. For graphite

$$\frac{\partial H^2}{\partial z} \geqslant 3{\cdot}6 \times 10^{14} \text{ A}^2/\text{m}^3 \approx 5{\cdot}7 \times 10^8 \text{ Oe}^2/\text{cm} \qquad (15)$$

Even if the strongest magnetic fields obtainable are applied, inhomogeneities of this order can be realized only over short distances, of the order of centimetres at most. Levitation of significant loads attached to the graphite particle is out of the question.

Braunbek[3] obtained levitation of small pieces of

bismuth (8 mg) and graphite (75 mg) in the magnetic field ($H_{max} \approx 23{,}000$ Oe) between specially shaped pole faces of an electromagnet (dissipating 530 W).

From simple dimensional considerations, it follows that, if a certain magnetic circuit is realized on a smaller scale, the maximum value of H necessary to obtain the same inhomogeneity $\partial H^2/\partial z$ decreases with the square root of a linear dimension.

If, instead of the diamagnetic substance, a material in the superconductive state is applied, the maximum value of the field strength at the surface of the superconductor may not exceed a critical value H_{max}. It may be conjectured that the vertical component of the pressure exerted by a magnetic field on the lower surface of the superconductor has a maximum value of $\frac{1}{2}\mu_0 H_{max}^2$. In the most favourable circumstances this pressure is zero at the upper side. Therefore, under the assumptions mentioned, the maximum value of the total lifting force per unit area of the horizontal cross-section of the superconductor will also be $\frac{1}{2}\mu_0 H_{max}^2$. For pure metals H_{max} is of the order of 10^3 Oe or 10^5 A/m. Higher values have been found for some alloys, e.g., $2{\cdot}3 \times 10^4$ Oe $\approx 1{\cdot}8 \times 10^6$ A/m for a Pb-Bi alloy. Even if only a small fraction of the value of $\frac{1}{2}\mu_0 H_{max}^2$ for this substance could be realized, the lifting force would be sufficient to levitate the superconductor itself, as well as a load of interesting dimensions.

Levitation of permanent magnets by diamagnetic or superconductive substances :—Consider two permanent magnets *in vacuo*, satisfying conditions in which (a) the magnets have no point(s) of contact ; (b) they are situated in such a way relative to a horizontal plane, and have such shapes and magnetizations that each magnet is the mirror-image of the other relative to the plane ; (c) the mechanical moment exerted by each magnet on the other is zero; and (d) the distance between the magnets is such that the repulsive force is equal to the weight of one magnet. It is easy to prove by experiment that such pairs of magnets exist. If the lower magnet is kept in a fixed position, the upper magnet has no stable equilibrium position. Only for horizontal displacements is the equilibrium labile.

Now, suppose that the lower magnet is taken away, and at the same time the half-space below the horizontal plane is filled with a superconductive substance. The magnetic field in the upper half-space can be obtained by superposition of the field of the remaining magnet and that of its mirror-image relative to the boundary plane.[4] This field will therefore be identical with that of the preceding case. The same is true for the moments and forces acting on the magnet. For horizontal displacements, however, the equilibrium here is indifferent, instead of labile, since the mirror-image always remains exactly vertical under the magnet. In this system levitation is therefore possible.

It is not necessary to fill the whole lower half-space with a superconductive substance, since the currents simulating the image are restricted to a very thin sheet bounding the horizontal plane. Furthermore, it is possible to realize the same repulsive force for a somewhat decreased height of the magnet, by means of a sheet of finite area situated vertically under the magnet. It can indeed be easily shown that the contribution of a small element of the sheet to the repulsive force varies inversely with at least the seventh power of the distance from the magnet. The effects of the edges of the sheet will cause the equilibrium to be labile instead of indifferent. Moreover, this lability can be changed into stability by making the sheet slightly concave at the upper side, because the fields, currents, and forces effecting levitation will change very little, as long as the radius of curvature of the concavity is very large, compared with the dimensions of the magnet, the sheet, and their distance, whereas obviously lability decreases.

This has been verified by Arkadiev[5], who succeeded in levitating a ferro-nickel-aluminium magnet, $4 \times 4 \times 10$ mm, having a mass of about 1 gram, above a concave superconductive lead disc, 40 mm in diameter, in a Dewar flask over liquid helium.

Now, starting from the system in which a magnet is levitated by a half-space filled with a superconductor, suppose that the superconductive substance is replaced by a diamagnetic material of relative permeability μ_r. This will cause the mirror-image to decrease in strength by a factor[4]

$$n = (1 + \mu_r)/(1 - \mu_r) \qquad .. \qquad .. \quad (16)$$

The repulsive force will decrease by a somewhat smaller factor n', because of the decreased demagnetization of the magnet by the now much weaker image. From simple dimensional considerations it follows that, if the model is reduced by the factor n' in all linear dimensions, the repulsive force will again exactly compensate the weight of the magnet. For the same reasons as given above it may be conjectured that there is no need to fill the whole half-space with the diamagnetic substance, and that stability can be obtained by making the upper surface of the diamagnetic substance slightly concave.

As the factor n of eq. (16) is practically inversely proportional to $1-\mu_r$, it is advantageous to use a diamagnetic substance with $1 - \mu_r$ as large as possible, such as Bi, for which $1 - \mu_r \approx 1{\cdot}6 \times 10^{-4}$ and $n \approx 1{\cdot}2 \times 10^4$. It may be expected, therefore, that a magnetized particle of suitable shape, and dimensions of at least a few microns, may be levitated above the concave upper surface of a piece of Bi with dimensions of a few millimetres.

Levitation of permanent magnets by permanent magnets and diamagnetics or superconductors :—From Earnshaw's theorem it follows that a permanent magnet cannot be levitated by means of one or more other permanent magnets alone, because of instability of the equilibrium position of the magnet. Of course, it is possible that this instability may be overcome by suitable application of superconductors or diamagnetics.

In an experiment with one of the most simple systems of this kind, the author did, in fact, succeed in obtaining levitation. A large permanent bar magnet M_1 with vertical axis attracts a small permanent magnet M_2 situated vertically below. For small horizontal displacements of M_2 the equilibrium is stable, whereas for small vertical displacements it is labile. This lability can be overcome by placing directly under M_2 a diamagnetic body with a horizontal upper surface at such a distance from M_1 that a small part of the weight of M_2 is compensated by the repulsive force exerted by the diamagnetic substance, the remaining part of the weight being compensated by attraction by M_1. If M_2 is sufficiently small, the repulsive force decreases so rapidly with increasing height of M_2 that the equilibrium for movements in a vertical direction is stabilized. In this experiment M_1 was a bar magnet with a length of 30 cm and a diameter of 3 cm ; M_2 was a small circular ferroxdure plate with a diameter of 1 mm and a thickness of 0·3 mm, magnetized parallel to the axis. The diamagnetic body was a piece of graphite, cut from high-purity arc-lamp carbon.

Quasi Stationary Fields

Earnshaw's theorem does not exclude the possibility of levitation in this case, even if $\mu_r > 1$ and $\varepsilon_r > 1$. Indeed, levitation has been obtained. Two cases are distinguished, as follows :—

Levitation of electrical conductors in alternating fields:— If an electrically conductive body is situated in an alternating magnetic field, currents will be induced in the body, counteracting the penetration of the field in the conductor.

Bedford, Peer, and Tonks[6] obtained levitation of an aluminium disc with a diameter of several decimetres in the field of a specially designed electromagnet fed by alternating current with a frequency of 60 cps. Okress and co-workers[7] obtained levitation of masses of a few hundreds of grams by means of a coaxial coil system, fed by an alternating current of about 700 A with a frequency of 10^4 cps.

Levitation in a quasi-stationary electromagnetic field with a feedback system :—The general apparatus for levitation of this kind comprises (a) a source for generating the field, (b) the body to be levitated, (c) a sensing element for the vertical co-ordinate of the body, and (d) a device for regulating the source in dependence of the output of the element (c) (feedback system) in such a way that the position of the body is stabilized.

In all published cases the source of the field is an electromagnet, mostly fed by direct current, although alternating current has also been used.[8] The levitated body contains a ferromagnetic material. The same kind of levitation can be obtained with a dielectric body in an electric field, but no record of this alternative is available. The sensing element is in most cases formed by a photocell and a beam of light partly intercepted by the body. A sensing element of a mechanical type has been suggested, and electrical types, either inductive or capacitive, have been used. The feedback system is always of normal electrical or electronic nature.

Masses of the levitated bodies range from 10^{-2} mg (Beams[9]) to 210 kg (Kemper[8]). The lowest power per kg so far obtained[8] is 1·3 W.

APPLICATIONS

Levitation by reaction forces has been practised by special types of aircraft vehicles as part of a landing scheme. In such other published applications as the author could find, levitation was obtained by forces in quasi-stationary electromagnetic fields.

The absence of mechanical friction for translational movements led Kemper[8] to the suggestion to apply levitation to such vehicles as trains. Arkadiev[5] suggested the revealing of superconductive inclusions in a body directly by scattering over its surface small magnets. These will roll to spots where superconductivity is absent. A levitated body can be used as a balance, because its weight can be found from the current passing through the magnet coil. Beams[9] obtained a precision of the order of 10^{-5} mg.

The absence of mechanical friction in rotation is often used to obtain high rotational speeds [9, 10, 11, 12, 13, 14]. The rotor, generally a small steel ball, is spun *in vacuo* by a rotating magnetic field. Beams[9] obtained a rotational speed of 8×10^5 revolutions per second and a centrifugal field in excess of 5×10^8 *g* with a steel ball of 0·1 mm diameter. Holmes[14] obtained residual frictions of 10^{-2} dyne-cm and residual torsional moments of 7×10^{-6} dyne-cm/rad.

Okress and co-workers[7] applied levitation *in vacuo* to the heating and melting of metals without a crucible. Small amounts (of the order of 20 grams) of Al and Ti could be levitated and melted. They suggest alloying techniques on this basis.

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Sonic Technique for Testing Leather

(*Concluded from page 236*)

of sound propagation should show no velocity decrease when width is decreased, since there is a sound path which travels directly through the specimen. For both types of specimen, experiment conformed with expectation. The 45-deg. cuts showed the same type of velocity-width relation as leather, and in parallel cuts the velocity was independent of the width within experimental error. The velocity of parallel propagation was also observed to be greater than the maximum velocity in the oblique direction.

Additional evidence that sound propagation follows fibre orientation was obtained from experiments with kangaroo-tail tendons. These tendons are composed of collagen fibres highly oriented along a single direction. The speed of propagation through the tendons was approximately 2000 m/sec or about three times greater than the speed in cattle-hide.

Another study showed that the speed of sound through leather increases with the period of ageing at 100°C until it reaches a maximum. Therefore, an indication of the quality of a sample of leather may be obtained by comparing the speed of sound through the sample with the maximum speed in a control specimen which has been subjected to ageing.

It is thus possible to detect changes in fibre orientation, without harming the specimen, by comparing sound-velocity measurements caused by strain, ageing, and filling. Moreover, there is good correlation between sonic measurements and the results of tensile and breaking tests. The effects of tannage, grease, and moisture can also be demonstrated. Finally, for an inhomogeneous material such as leather, the sonic technique has the distinct advantage of providing a means of following the effects of ageing, chemical treatments, etc., on a single specimen.

British Industrial Developments

Gas-Turbine Test-Building and Propane Gas Fuel Plant

The new gas-turbine test-building and propane gas fuel plant of Ruston and Hornsby Ltd., of Lincoln, are the first of their kind in Great Britain and are among the few at present in existence in the world.

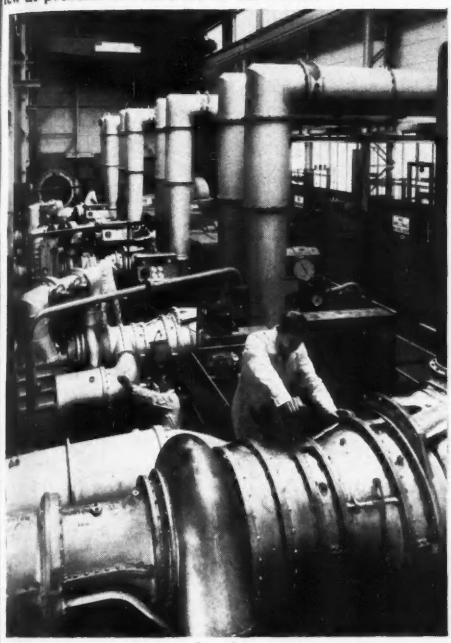


Fig. 1.

The gas-turbine test-building, although of moderate size, permits six turbines to be tested simultaneously on various types of fuel. Furthermore, the site allows for additional expansion of test facilities and of fitting and erecting capacity. The building is of steel-framed construction, and is 132 ft in length by 52 ft in width by 38 ft 9 in. to the under-side of the roof members. The width of 52 ft includes an 11-ft annexe, which provides the main shop gangway and supports the air inlet-filter gallery at ceiling level. This gallery runs the full length of the building on the south side, and air is drawn in through fixed aluminium louvres. At the west end, two intermediate floors in the annexe are used for offices and fine fitting work, etc. At the east end, a fixed high-level gallery provides a further bed for testing those turbines which will operate with heat exchangers. A large area of the interior of the shop is lined by acoustic tiles, providing combined thermal and acoustic insulation. These tiles are perforated metal trays containing fibre glass. In addition to having a high fire resistance, they were chosen as being reasonably easy to dismantle and re-erect on the two sides on which extension is expected. While the noise of turbines running is not noticeably contained, reverberation within the shop is lessened and good working conditions are achieved. Fig. 1 shows the general layout of the building, with five turbines in position. Sections of the acoustic-tiled walls can also be seen.

Lighting throughout the shop is fluorescent, fixed in most cases to continuous trunking. Each crane-track carries one row of fittings and there is a central row in the roof. Heating is by high-pressure hot-water radiant panels. The heat from the turbines under test can be fully utilized, since the panels are automatically regulated by atmospheric temperature.

The shop has been largely designed around the standard Ruston TA turbine, although provision has been made for two beds on which very much larger units can be tested, if required. Six beds are provided, one vehicle-entry bay, and one bay for unloading, packing, and dispatch. Two beds at the east end are available for heat-exchanger sets and have been arranged so that most site conditions can be reproduced on test. All services are placed below ground level. Service trenches carry oil-fuel lines, compressed air, welding, power, and test cables, liquid-propane fuel, and river and towns water. Branches carry the services from the main ducts to individual beds. A 25-ton overhead crane, geared to 8 tons, copes with all turbine and driven-machinery loads and most heat exchangers. Inlet air for the turbine is taken from the outside atmosphere into the filter gallery. Each turbine bed has its own individual filter unit, which can be moved into position to suit the air inlet connections of the compressor. The frame on which the filter sits supports the venturi, silencer, and standard connecting ducting, which hang vertically and are also designed to meet most standard arrangements of compressor inlet. The twin exhaust ducts are taken to the north side of the shop, where they connect, via a breeches piece, to a permanent outside stack.

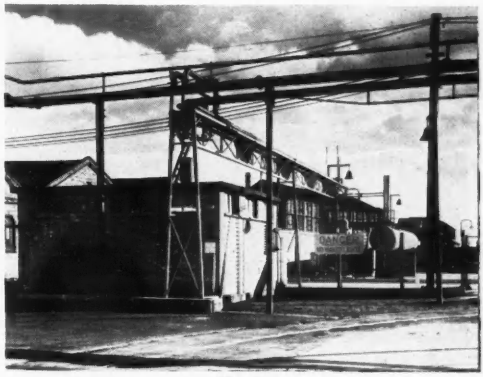
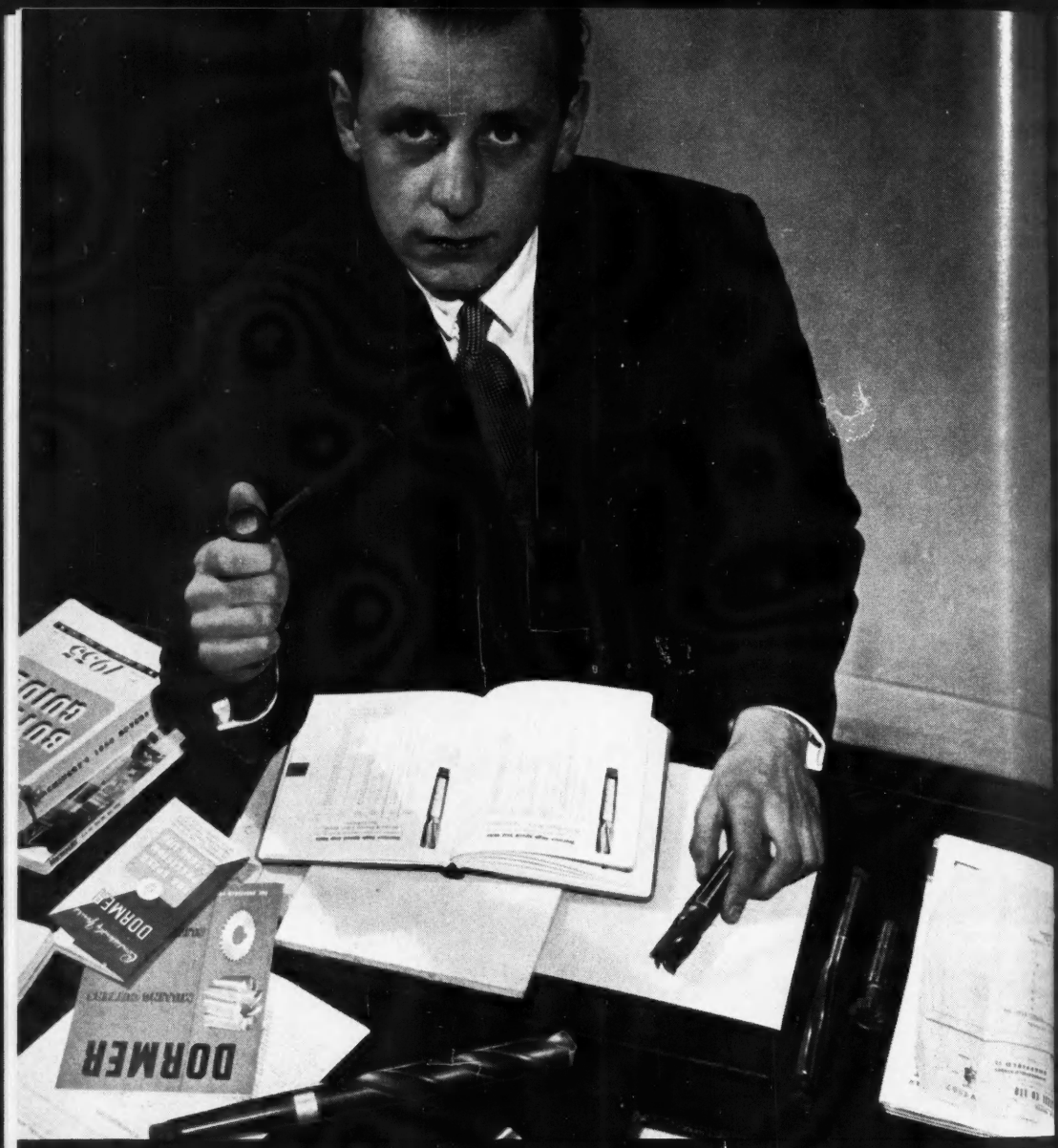


Fig. 2.

The propane gas fuel plant will supply a gas mixture which can be delivered to the gas-turbine test-room with a heating value which is adjustable between 600 and 1200 B.T.U./cu ft. The propane is brought to the works by road tankers equipped with transfer pumps. Each of the two storage tanks, with a total capacity of 25 tons of liquid propane, is fitted with four relief valves, interconnected so that at least two, which have adequate capacity to protect the vessel against over-pressure, are always locked in the open position. All pipe lines entering or leaving the vessel are protected by excess-flow valves or non-return valves located inside the vessels. Excess-flow valves will shut off automatically when a dangerous quantity of gas or liquid flows away from the tanks, e.g., in the case of pipe rupture.

In operation, liquid propane flows from the bottom of a storage vessel to the steam-heated evaporator, after passing through a pneumatic control valve which is



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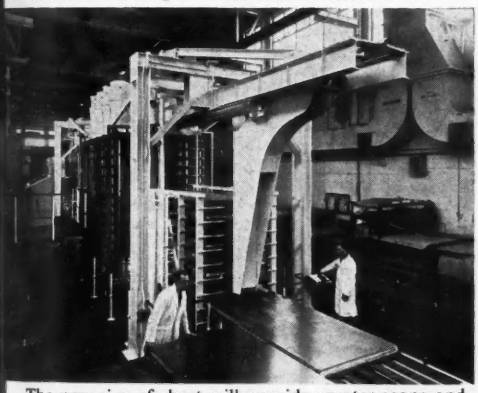
governed by a level-controller on the evaporator. The steam supply, delivered at a constant pressure, passes through a pressure-control valve influenced by gas pressure in the evaporator and instrument air tapped from the compressor house to maintain the pressure in the evaporator and storage tanks. The vapour delivery is throttled, by twin reducing valves, to a constant pressure of 150 psig.

The compressor house contains two twin-cylinder, two-stage, water-cooled air compressors, supplying high-pressure air, which, after passing through after-coolers, is delivered with the propane gas to the test shop. The air and propane lines run together, steam-traced and insulated, to maintain a uniform temperature difference at the mixing station. Fig. 2 is a view of the propane gas fuel plant, and shows the compressor house in the foreground, and the storage vessels behind. The storage tanks and evaporator are located within a fenced safety zone bearing no external combustible material. Electrical gear within the area is flame-proofed and the storage vessels are earthed to a point used also by visiting road tankers. A drencher spray system is to be fitted to the storage vessels. This installation, which is dry until operated by a manually operated switch from a remote point, will give protection against excessive heat.

New Hydraulic Press for Formica Laminated Plastic

A new 6100-ton hydraulic press (eight columns with eight rams) for producing laminated plastics in Great Britain is now in operation at the Tynemouth factory of Thomas De La Rue & Co. Limited, and permits the manufacture of 10 × 4 ft sheets of Formica laminated plastic for the first time. The decision to add a longer sheet, 10 × 4 ft, to the existing range of sheet sizes was reached after investigation and market research.



The new size of sheet will provide greater scope and prove more economical to some manufacturers, as its proportions will allow a greater number of useful panels to be cut from it without wastage. Furthermore, it will be produced in the same grades, colours, and patterns in which the other sheet sizes are available.

Slab Insulation Material

A new slab material, designated " Insulex ", combining the best features of both moler, i.e., diatomite, and fibrous types of heat insulators, has recently been introduced by Moler Products Ltd., of Colchester. Of particular application in the insulation of large wall surface areas, Insulex possesses ample mechanical strength, and is quick and easy to install. Its temperature limit is 1700°F, and its exceptional insulating efficiency results from the combination of diatomaceous earth, asbestos fibre, and exfoliated vermiculite used in its manufacture.

Steel furnaces, high-pressure boilers, and gas retorts are all being increased in size, and the requirement is an insulation material which can be easily installed with a minimum of joints over large, flat wall surfaces with sufficient mechanical strength to resist settlement. In these, and all " back-up " applications, Insulex provides acceptable and efficient insulation—used either alone or in combination with insulating and insulating refractory bricks, according to structural requirements and temperatures. As Insulex is most frequently used in plated wall constructions, a special liquid adhesive is supplied for fixing to the metal casing pending the erection of the brick lining. The adhesive is also suitable for securing the slabs to brick surfaces. Insulex slabs are normally laid dry, the sharply defined edges ensuring minimum heat loss at joints. A special mortar is available, however, to provide continuity of insulation, if preferred.

Insulex is available in five standard slab sizes, ranging from 24 × 6 in. to 36 × 12 in., and five thicknesses, from 1 to 3 in. Non-standard sizes can, however, be made.

High-Speed Precision Mixers

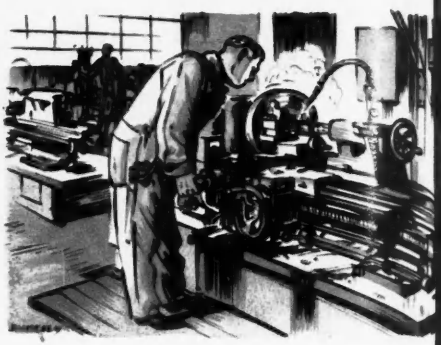
An entirely new type of machine, the Lödige/Morton precision mixer, claimed to be the fastest in the world for mixing pulverized, granulated, and fibrous materials, is now in production at the Wishaw factory of the Morton Machine Company Limited. Designed and developed in Germany, these machines range from laboratory models of one quart capacity to production machines with a capacity of 5500 gal, and are capable of solving numerous complex mixing problems in a wide range of applications, in many cases reducing from hours to minutes the time taken for the mixing operation.

The Lödige/Morton machine consists of a cylindrical mixing vessel with a set of revolving shovels mounted on arms attached to a shaft. These shovels are double-plough-shaped and are so designed that the mix is thrown upwards and outwards, ensuring that the materials are intermingled in space. This method is entirely different from previous techniques based on forcing the ingredients against each other to achieve the mix. As the shovels pull the mix away from the vessel, there is no possibility of any pressing action which might destroy the particle size of the ingredients. Owing to the special shape of these shovels, even fibrous materials, which are particularly difficult to handle, can be mixed with a minimum amount of damage. For certain types of mixes the cylindrical vessel is designed to revolve in the same direction but at a slower speed. The materials are constantly thrown upwards, ensuring re-mixing many times within a few seconds, eliminating the risk of heavier elements remaining at the bottom. This method enables materials of widely differing densities to be efficiently mixed, e.g., iron powder and graphite.

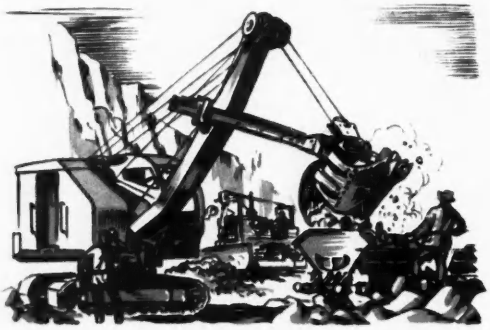
An average-size Lödige/Morton machine is the M 100 D, driven from a 2- or 3-hp electric motor through V-belts to the shovel shaft. The machine can be supplied with mixing vessel and shovels in mild or stainless steel. The shovel shaft is mounted on ball races, sealed to prevent the mix escaping from the container or dust from entering the races. Additional equipment includes dust-proof filling and emptying containers and sifting screens arranged overhead. Rubbing and grinding attachments can be fitted for working a liquid, oil, or fat into a powder. Such a mix can be achieved in certain circumstances in under 10 min, when the mix is discharged as a dry powder, with the liquid, oil, or fat finely dispersed within it.

A Lödige/Morton machine has been developed for the production of P.V.C. by the dry powder method. By this means vinyl chloride polymers, fillers, and plasticizer can be mixed to a dry powder in the presence of heat, and can be fed straight into a cable extruder, eliminating costly mixing rolls and mills. Where necessary, up to 50% of plasticizer can be added to suspension-type P.V.C. by this method. Two sizes of these machines are available,

Iron and Steel Rolling



Machine Tools



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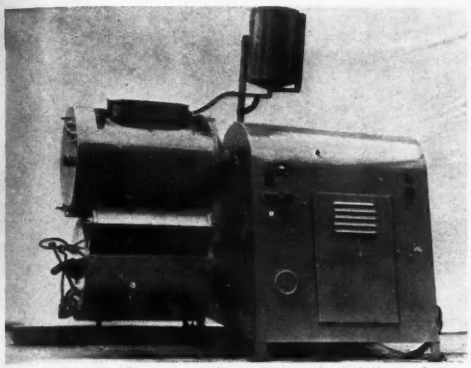


capable of handling respectively 300 and 1400 lb per hour. The 300-lb model is illustrated. These mixers are supplied with a jacket for steam or hot oil, working up to a temperature of 150°C. The mix is discharged after the heating process into a water-cooled mixer under the hot vessel.

Graticule for Unified Thread Forms

The availability of a new graticule, manufactured to B.S.S. 1580/1953, for inspection of unified thread forms with the O.M.T. toolmakers' microscope, is announced by Optical Measuring Tools Ltd., of Maidenhead, Berks, a subsidiary of The Newall Engineering Co. Ltd. Believed to be the first of its type produced in Great Britain since the decision was made to adopt the unified thread form in the United Kingdom and U.S.A., a feature of the new graticule is that it completely covers the thread forms for both nuts and bolts from 4 to 40 t.p.i. To simplify inspection and to eliminate any possibility of confusion, the forms for bolts and nuts are imaged in separate sections of the graticule. A National Physical Laboratory report on the graticule indicates that the accuracy produced in employment would be of the order of 0·00017 in., as against the 0·0005-in. tolerance for thread forms being measured permitted in the N.P.L. specification of accuracy of a toolmakers' microscope.

Production of the graticule commences in the drawing office with each thread form being drawn to a scale of 96:1 on specially prepared aluminium sheets. For this purpose a special table is employed with accurately bored holes at 1-in. intervals on the perimeter. These holes accept ½-in. lapped plugs, against which a straight edge is located to give ½-in. distances. Along the straight edge runs a pen carriage incorporating a vernier scale subdividing the ½-in. divisions into 0·001 in., thereby ensuring that co-ordinates are accurate to this measure. The table is also used to obtain correct dimensions for the radii drawn with trammels. Master intermediate negatives, one-eighth of the size of each thread-form drawing, are then made, so that, at this stage, the photographic image is 12 times the size of the actual thread form.

Numerous factors had to be considered in devising copying equipment which would maintain accuracy during the reproduction process, including the mounting and alignment of the camera and lens mount. The copyboard, lens mount, and plate carrier are all parallel to each other within 30 sec of arc, and, to avoid any deviation from the vertical or horizontal plane, the master drawings are retained on the copy-holder by a vacuum system. The photographic plates used are of the maximum-resolution type, and strict temperature control is observed in processing to prevent emulsion distortion.

The most intricate stage of production is the preparation of the master graticule, involving a separate exposure of each intermediate thread-form negative, all correctly spaced and positioned according to size onto one plate. This is carried out in an underground optical dividing room, temperature-controlled and insulated against shock. A reducing camera is employed to give an image one-quarter of the size of that on the intermediate negative and, therefore, 3 times the scale of the actual thread form. The instrument which embodies the finished graticule magnifies the object under inspection by a factor of three to compare with the graticule size. A beam of light projects by reflection the image onto a grey setting-screen for correct positioning ; when this is accomplished the mirror in the optical system is displaced, thereby permitting the image to travel through a prism, causing inversion. Located under the prism is a sensitized photographic plate centred on a 10-in. O.M.T. rotary indexing table, which is set at zero prior to the intermediate negative with a 60-deg. angle being exposed. The table is then indexed on and exposures made at decreasing intervals, proportionate to the diminishing bolt-thread forms being projected. This takes up to 220 deg. of the surface, and is followed by projection on identical lines of the nut-thread forms, which are accommodated in the remaining 140 deg. Correct exposure is of immeasurable importance in production of this master positive plate and is controlled throughout by electric impulses from a synchronome clock.

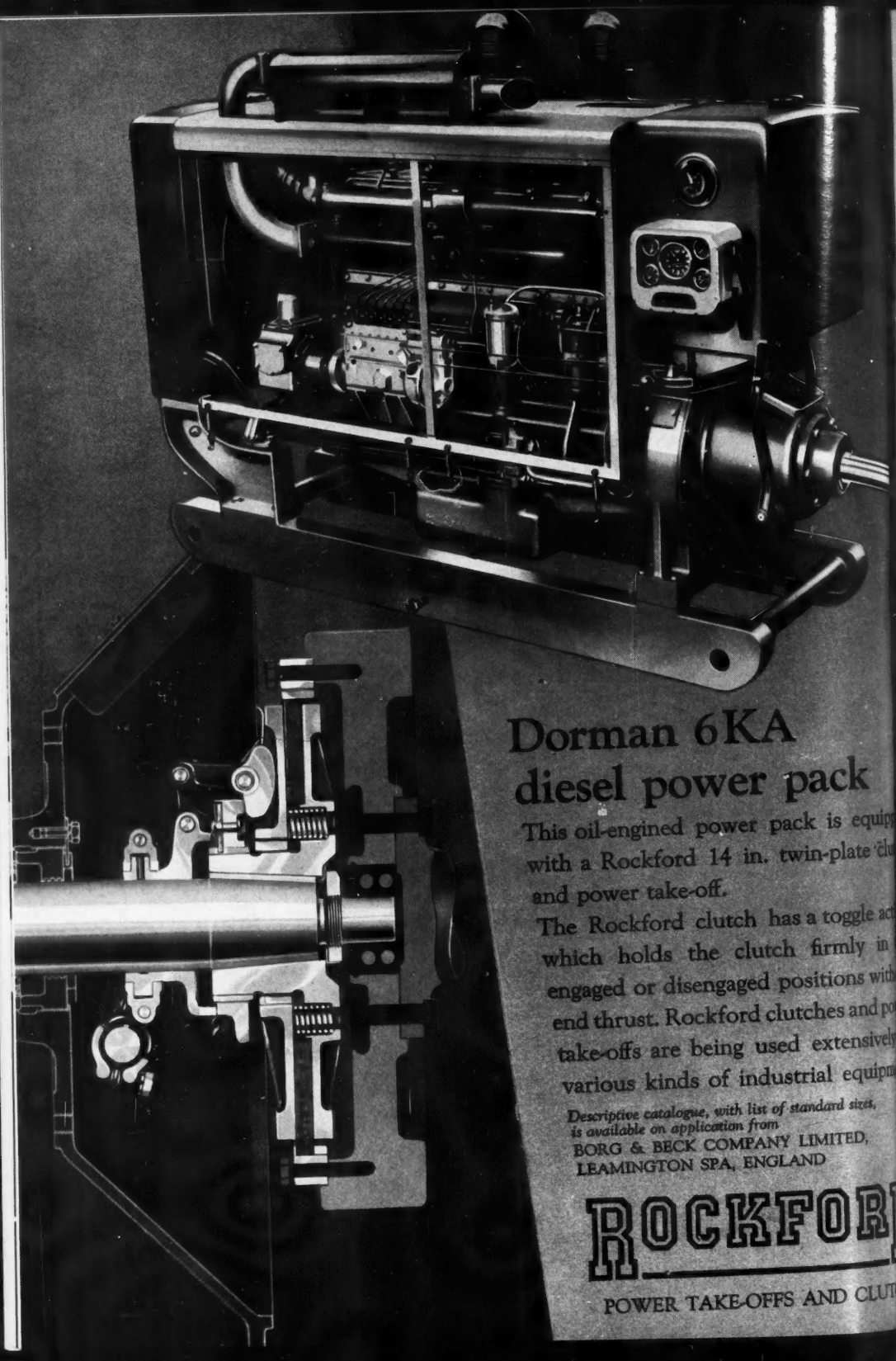
In the final stage photographic prints are taken from the master onto graticule blanks, ground and polished in the optical division of the Company. After chemical cleansing, the blanks are coated with a light-sensitive bichromate fish-glue emulsion to a thickness of 0·0001 in., and dried and exposed in a vacuum frame to ensure perfect contact. Development is by running water, which removes unexposed emulsion and leaves a transparent image, later made opaque by application of a dye. Subsequently, the graticule image is chemically hardened, thoroughly cleaned, and mounted in a sealed ocular to obviate intrusion of dust and atmospheric fumes.

Instrument for Rapid Measurement of Ferrite Content in Austenitic Metals

In general, the only method of checking the percentage of ferrite in austenitic weld metals has been by means of laborious and time-consuming laboratory tests. Recently, however, a new and rapid method, applicable to the ferrite content of welds, rods, sheet, and fabricated components, has been developed by the East Lancashire Chemical Co. Ltd., of Fairfield, Manchester, and is based on a modification of their Elcometer, which was originally developed for measuring the thickness of non-magnetic layers (e.g., paint and plastic coatings) on magnetic surfaces.

The Elcometer is a pocket-sized instrument operating on the principle that the increase of magnetic flux intensity between two soft iron test-probes of a U-shaped magnetic circuit reduces the forces on a spring-loaded magnetic needle in a parallel magnetic branch.

For the measurement of ferrite content in an austenitic metal, the tension of the spring is adjusted so that the needle on the scale gives a reading corresponding to the ferrite content of a reference sample. Although the readings obtained are not as strictly accurate as those obtained by laboratory tests, they are sufficiently accurate to be of immediate practical value.



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BEARINGS

The Development of Metal-Bonded Carbon Bearings.
By H. B. NUDELMAN, C. H. SUMP, and W. C. TROY. (From *ASTM Bulletin, U.S.A.*, No. 213, April 1956, pp. 62–69, 8 illustrations.)

THE investigation described in this paper has resulted in the development of a water-lubricated bearing material capable of performing in water at temperatures of 200°F and over. Efforts were directed toward the interpretation of wear technology in the case of heated-water bearing applications. A study of methods of combining and bonding carbon and metals was made. A 70–30 Ni-Cu solder and 70–30 Co-Cr alloy were the principal metals used. Very effective bearings were made with the cobalt-chromium alloy, as revealed by water-lubricated sleeve and thrust-bearing tests.

The effect of metal-binder content on the impact resistance and compression strength of cobalt-chromium-carbon composites was examined. Compression and impact specimens of varying metal-binder content were prepared by hot-pressing techniques. The ratio of cobalt to chromium (70/30) was not varied, for it provided the highest hardness without the brittleness associated with alloys of higher chromium content. The effect of finer mesh sizes of carbon on the mechanical properties of this system was also investigated. Finer carbon particles would have been required if bodies of higher metal-binder content proved desirable, as a problem of adequate distribution is involved in this instance.

Material design efforts were directed towards the embodiment of the combined impact resistance of metallic materials and the anti-friction properties of carbon. An interrupted structure of metal-bonded carbon was developed on the basis of theoretical consideration and experimentation. This material demonstrated greater impact strength than carbon, the material currently in use for this application. Sleeve and thrust-bearing tests served to show that, in addition to improved mechanical properties, adequate bearing characteristics had been retained. Hardness proved to be a necessary requirement of the metallic matrix. It was demonstrated that, for thrust-bearing applications, the surface finish of metal-carbon composites ranks at least equally in importance with surface contour for maintaining a hydrodynamic film. Without this film, it is doubtful if wear can be prevented if metal-to-metal contact is established.

The authors recommend the 70–30 Co-Cr alloy matrix with carbon additions of 60 to 70% by volume for further bearing development. This composition increases the usefulness of the cobalt-base alloys in this application. Hot pressing as a fabrication technique to-day is a commercial reality. Possibly, flash-sintering by resistance heating is an alternative production method. Apart from this, a large saving in critical cobalt alloy is realized by the addition of 60 to 70% by volume of carbon.

FLOW OF FLUIDS

Three-Dimensional Motion in Axial-Flow Impellers.
By S. P. HUTTON. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, May 4, 1956, 11 pages, 16 illustrations.)

PROPELLER pumps and fans are usually designed by assuming that the performance of each individual section of blade is unaffected by its adjacent conditions ; it would, therefore, behave in a similar way to an aerofoil of infinite span having the same profile. In other words, the flow round the blades is assumed to be two-dimensional, a condition which is only perfectly realized when the whirl distribution corresponds to that in a free vortex. This condition is frequently assumed to exist, but is seldom encountered in practice, for even free-vortex-type machines will only give two-dimensional flow at the design point. In addition, it has become apparent that, for special high-head duty, or good cavitation performance, other designs than free vortex can be used with advantage. Such departures from the ideal cause three-dimensional motion which cannot be accounted for by the simpler design methods ; thus, discrepancies between designed and measured performance tend to arise. Several methods to overcome these defects have been suggested, but most of them are very laborious and are more appropriate to high-pressure-rise compressors.

It was the object of the research described in this paper to investigate three-dimensional effects in simple low-pressure impellers, to ascertain whether existing theories should be modified to allow for them, or a new theory developed to predict performance more accurately under three-dimensional conditions.

Detailed surveys have been made of the flow through a low-pressure-rise axial-flow impeller (hub/tip diameter ratio 0·33), which did not produce " free-vortex " whirl distribution. It was found that (1) at all flows, centrifugal forces caused large variations in axial velocity component through the rotor ; (2) the angular direction of the flow varied considerably within a short distance of the rotor, and the flow did not stabilize until about two blade chords downstream ; and (3) as the tip clearance was increased, secondary motion was induced opposite to the motion caused by centrifugal effects and, for clearances greater than 1% of the blade height, seriously restricted the use of radial equilibrium theory.

The measured head-flow characteristics for various sections along the impeller blades did not agree well with those calculated by the following two-dimensional design methods :—(1) " Slip " theory, (2) " cascade " theory, and (3) " aerofoil " theory. Better results were given by the use of a new method which consisted of two steps, i.e., (1) calculating the change in axial velocity by the radial equilibrium theory, involving the use of cascade data ; and (2) calculating the head-flow characteristics, using the aerofoil theory based on the mean axial velocity obtained from (1). By this compromise the calculated local performance over most of the blade agreed within 4% of experiment for a wide range of flows between design point and the stall.

IRON AND STEEL

Developments in Shot-Blasting Strip Steel.
By K. R. KESKA. (From *Iron and Steel Engineer, U.S.A.*, Vol. 33, No. 3, March 1956, pp. 65–72, 6 illustrations.)

MECHANICAL descaling or shot-blasting is an airless principle where shot is hurled at high velocity onto the work, using centrifugal force to motivate the shot. The method used in small foundries of air-blasting round steel pellets against castings to clean off scale and sand is a well-known process. However, in an operation where a large surface is to be cleaned, the amount of shot necessary to provide a clean surface, when carried by compressed air, makes such an operation prohibitive, owing to the cost of the compressed air. To-day, centrifugal blasting is the accepted practice for commercial use, including the cleaning of castings, forgings, and rolls,

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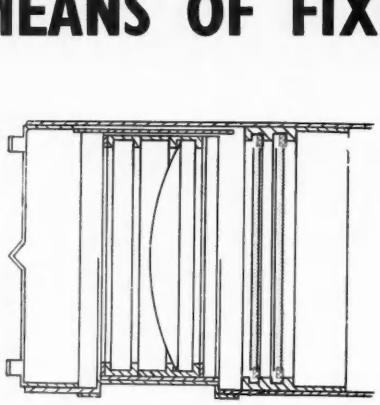

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as well as flat rolled products. The shot discharge from the blasting wheel is controlled to a definite pattern in order to be able to concentrate the area of cleaning and to reduce the wear on the enclosing cabinet.

Despite the fact that, as indicated in this article, blast-cleaning undoubtedly has many inherent advantages, it is reasonable to conclude that, at the present stage of development, it will not replace pickling as a method of scale removal where the material is to be cold-reduced. Acid pickling produces a cleaner product at higher production rates and lower operating cost, especially in high-speed mass-production operations. Nevertheless, it would appear that shot-blast cleaning equipment has a definite place in the operations of those manufacturers who, at the present time, use hot-rolled pickled steel, and especially those who later coat their products with paints, oxides, or some type of metallic coatings.

It has only been since 1950 that any real activity has been evident in the field of shot-blast cleaning, with reference to flat rolled products, and it seems clear that, up to now, very little has been done, insofar as applications of this type of equipment are concerned.

MAGNETISM

Vibrating Permalloy Probe for Mapping Magnetic Fields. By J. KACZER and R. GEMPERLE. (From *Czechoslovak Journal of Physics, Czechoslovakia*, Vol. 6, No. 2, April 1956, pp. 173-184, 18 illustrations.)

A METHOD using a vibrating permalloy probe has been proposed and elaborated for mapping the magnetic field on the surface of ferromagnetic materials. As the probe is capable of recording microscopic stray fields on the surface of ferromagnetic samples, it can also record stray fields produced by flaws in their surface, such as cracks, holes, unevenness, and non-magnetic inclusions.

The effective part of the probe was made of a material with a high initial permeability, in this case from a permalloy sheet, 0·05 mm in thickness. The probe was cut from the material in the shape of a strip which tapered to a point at one end, reduced by electrolytic polishing to a few microns, the radius of the point depending on the kind of field to be mapped by the probe. The wider end of the strip was cemented to a piezoelectric crystal, which served to drive the probe in the neighbourhood of its lowest flexural mode. For this purpose, a quartz bar, 1·5 × 5 × 56 mm, was used, clamped at one end and oscillating with an insignificant amplitude and with a frequency well below the lowest flexural mode of the crystal. The sensitivity of the probe is proportional to the velocity of its point, and this velocity can be increased both by increasing the amplitude and the frequency of oscillation.

This paper, in addition to the probe, describes the whole equipment used and its properties, together with indications of the results achieved.

WELDING

A Weld-Cracking Susceptibility Test for Sheet Materials. By J. S. BOUDREAU. (From *The Welding Journal, U.S.A.*, Vol. 35, No. 4, April 1956, pp. 164s–168s, 8 illustrations.)

HOT cracking due to welding in many high-temperature alloys, particularly the precipitation-hardening types, has been a major deterrent to their adoption for use in fabricated assemblies. From a welding standpoint, to attempt substitution for an established material, or to evaluate new materials, treatments and alloy modifications usually involve a trial-and-error procedure, incur considerable expense, and are time-consuming. Even then, in many cases, successful results cannot be realized. Although many potential material substitutes and improvements exhibit desirable or superior mechanical and physical properties, the lack of information about their behaviour when welded, or during welding, precludes their immediate use.

It is a well-established fact that restraint cracking, i.e., cracking which occurs when weldments or base metals are unable to withstand the stresses set up in a rigidly held joint, is a major fabrication problem. This effect is accentuated by the fixturing necessary for welding assemblies, which must be held to extremely close tolerances. While this property has not been favourable in fabrication, it has been made to work to advantage in testing.

A very promising test employing this principle has been developed and is described in this paper. This test consists of applying a definite, steady tensile load to a sample of sheet stock while an inert-arc weld is made normal to the axis of loading, without filler being added. Thus, a substantially unidirectional, measurable stress is applied to a specimen while it is welded under conditions which simulate the stress due to welding and to the resulting thermal expansion and contraction. The stress level at which cracking is initiated is an index of the weld-cracking susceptibility of the material, and rapid determinations can be made with a minimum of preparation and evaluation.

It is felt that the weld-cracking susceptibility test described is a reliable tool for the determination of the weldability of specific materials. It is also useful for the evaluation of the effects of variations in compositions, heat treatment, melting practice, and other processes on welding behaviour and on hot-tearing properties. Its greatest value, however, may come in furthering a better understanding of the nature of weld cracking as affected by incipient melting phenomena, precipitation-hardening mechanisms, solidus-liquidus gap, and other factors.

WIRE ROPES

The Effect of Wear and Tear on the Serviceability of Wire Ropes.

By E. A. FRANKE. (From *Draht, Germany*, Vol. 7, No. 4, April 1956, pp. 124–129, 8 illustrations.)

IN many applications, wire ropes are exposed in early use to relatively high stresses, and the danger of complete fracture is especially great if, for various reasons, the specific loading increases. Tests hitherto carried out on wire ropes have generally been confined to determining their tensile, bending, torsional, and fatigue strengths ; however, because of the lack of suitable test equipment, little attention has been paid to the increased stresses arising from wear and tear, which, in a wide variety of equipment, can be quite considerable, so much so that there is always the possibility of wire ropes breaking from this cause alone.

In view of the great importance of the effects of wear and tear on the serviceability of wire ropes in many installations, tests should, in addition to those normally applied, also be made in the interests of safety and economy to determine their wear resistance and the effects of friction arising from winding and unwinding on drums and from lateral contact between turns. To provide useful data, such investigations should be carried out in such a way that the stresses to which the testpiece is subjected simulate as far as possible those occurring in service. This article describes simple test apparatus suitable for this purpose and shows how it may be adapted for duplicating actual service conditions in a number of typical installations. Thus, for example, it can be used for testing suspension cables and haulage ropes of cableways, for funiculars, and for wire ropes in general, where wear and tear occur through rolling friction. Similarly, simple apparatus can be designed for simulating wear-and-tear conditions for wire ropes on winding drums, with or without the incorporation of rollers for determining the effects of rolling friction.

It is believed that, despite inevitable scatter in some of the results, these in general tend to follow a pattern which enables a test programme to be cut down, without impairing the accuracy of predictions regarding behaviour in service, especially if static methods are also used in evaluating test results.

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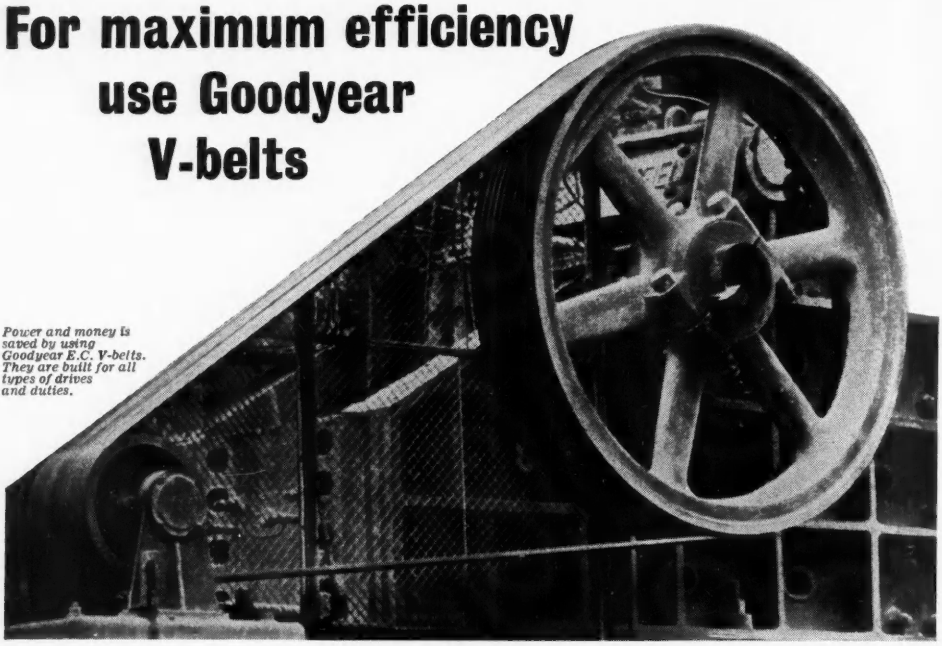

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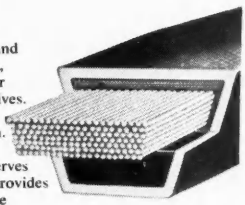

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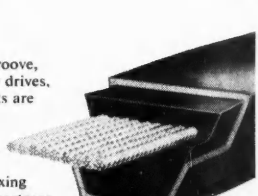

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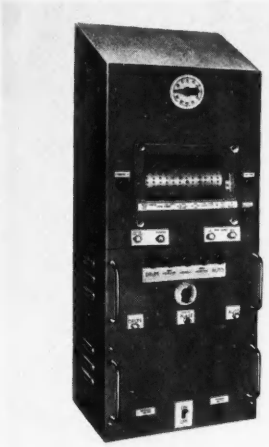
Designed to perform automatically the main operating functions associated with continuous cinema performances, the " Projectomatic " system announced by G. B.-Kalee Ltd., of London, W.1., is so arranged that the sequence in which the various functions are carried out is determined by pins set in a rotating drum, or, in the case of change-over operation, by marks on the film. Once the drum has been set up and the film marked prior to the first performance, the show will run continuously without further action by the operator other than to clean and lace the projectors, renew carbons, and change discs on the non-sync.



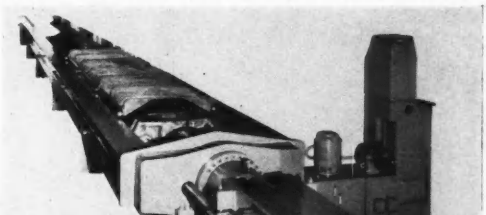
The equipment consists of a main control cabinet and a number of relay units which are operated by signals received from the main control unit, and which in turn control the various switching functions on the projection equipment. In addition, special rollers are fitted on the projectors to detect the film marks and to operate an emergency-stop circuit in the event of a film break or mechanical failure. The actual functions which can be performed by the system, according to the type installed, include starting and stopping of the projector motors, striking and extinguishing of the projector arcs, opening and closing of the dowsers, starting and stopping of the non-sync. motor, change-over of picture and sound (single-track optical or multi-track magnetic), control of the amplifier system for sound on film to non-sync. and *vice versa*, opening and closing of curtains, dimming up and down of footlights and houselights via a reactor dimmer, and screen masking for three aspect ratios. In addition, a colour-selector system can be fitted, giving facilities for preselection of various combinations of three colour circuits or houselights.

The pin drum, which is housed in the main control cabinet, is furnished with rows of holes spaced at regular intervals around its circumference. The drum is rotated in steps by a solenoid operating through a ratchet mechanism, each step being equal to the space between two adjacent rows of holes. Each hole in every row corresponds with a particular function and is associated with a microswitch which operates when a pin is inserted in a particular hole. The solenoid coil is controlled through a thyratron circuit with a variable time delay and, by inserting pins in the appropriate positions, it can be made to step round at regular time intervals. A timer clock is also fitted for use when a longer interval between operations is required.

For automatic change-over operation, a pin is set in an appropriate position on the drum. The control of the various functions associated with change-over is now entirely dependent on the film marks, and the drum has no further influence until the end of the last reel. Where a change-over is required, three marks are placed on the film towards the tail leader. The marks are made by applying an electrically conducting lacquer to the film in the region of the perforations. When the first mark passes the detecting roller, it causes various relays to operate in the control unit and a warning buzzer sounds, indicating to the operator that a change-over is about to take place. The next mark follows within 15 sec running time and operates further relays, which start the motor of the incoming machine and strike the arc by the direct application of power, a fusible pellet having been placed between the carbon tips by the operator during the unoperated period. The outgoing machine continues to run until the third mark passes the roller, when its dowser is closed, its arc lamp extinguished, and its motor stopped. At the same time, sound change-over takes place.

CHAIN- AND CABLE-TESTING MACHINE

A new type of chain- and cable-testing machine, for loads up to 200 tons, has been developed by Karl Frank G.m.b.H., of Weinheim-Birkenau, Germany, and is intended for destructive tests on chains, wire-conveyor cables, wire-hoist cables, and hemp rope. The equipment consists of the testing machine proper, a pendulum-type load indicator, an oil pump, and accessories. The machine is so designed that the line along which the load is applied and the centre of the bed-plate are coincident; as a result of this arrangement all forces are absorbed integrally, and the foundation has to support only the dead-weight of the machine. The pendulum-type load-indicator automatically indicates the load exerted on the testpiece. Four test-ranges are available, i.e., 0–200, 0–100, 0–40, and 0–20 tons respectively. A pointer shows the maximum loading achieved in the course of a test. An oil brake is connected to the pendulum of the load indicator, ensuring a slow return of the pendulum after the testpiece has failed. In the no-load position, the pendulum swings freely. The clamping head or chuck on the piston rod moves on ball-bearing-mounted rollers over a smooth track; the rolling friction between the



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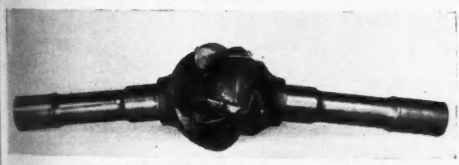
rollers and the track therefore has negligible effect on the accuracy of the load indication. The load-measuring device, with the cylinder of the machine on its pendulum suspension and the clamping head on the piston rod, are all situated at one end of the machine; at the other end there is another clamp, mounted on a cross-head which can be moved along the bed by a hand lever and which is secured in position by bolts at intervals of 1 metre.

A removable guard is fitted to protect operators from testpieces which come adrift. Special clamping devices for destructive and stretching tests are supplied, and these are capable of holding testpieces securely up to the maximum loading of 200 tons. Clamps for securing chains consist of holders and clips, suitably proportioned to accommodate chain links of diameters from 5 to 40 mm. Hemp ropes of from 3 to 70 mm in diameter may be tested satisfactorily, using special rope holders. Even the more complicated problem of securing wire cables has been solved by casting a conical slug onto both ends of the testpiece, these slugs being clamped in suitable holders. This method enables wire cables from 9 to 75 mm in diameter to be tested. In addition, provision is made for standard tensile testpieces.

CONSTANT-VELOCITY UNIVERSAL JOINT

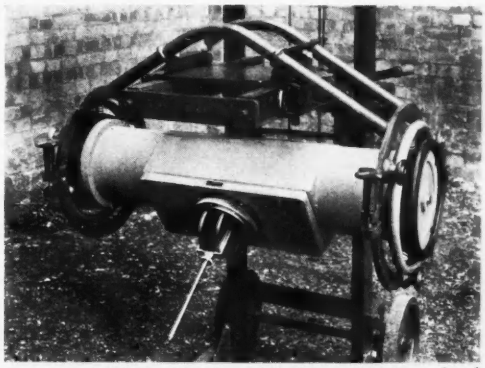
In conventional universal joints, if constant velocity is required, at least two such joints must be used and, if a composite joint is desired, arrangements must be provided for automatically moving the axis of the intermediate component in such a way as to bring about the necessary similarity of the angles made by the driven and driving shafts. The new Garrington constant-velocity joint, developed by Garringtons Limited, of Bromsgrove, Worcs., does not suffer from these disadvantages. Designed with rocking pads, the flat faces of which are constantly on right-angled planes, the contact areas are in identical positions on both the driving member and the driven member at all angles of its coverage. In other words, the pressure areas of the driven member are a mirror image of the driving areas.



As a result of the joint faces being at right angles to each other along the axis of the joint, there is no axial load; furthermore, the joint can move, within reason, in and out of mesh under power, and is self-supporting. The Garrington joint comprises two main members only and needs no intermediate component; the generous pad areas are so designed as to reduce loading, and the main loads are of the compressive type. Where two joints are used in tandem, e.g., for two parallel shafts not on the same axis, the relativity of the joints to one another is unimportant, and the angle which can be covered is of the order of 35 deg. in each joint.

PORTABLE INDUSTRIAL X-RAY UNIT

Combining the ideals of high rating and portability, a new industrial X-ray unit has been introduced by Philips Electrical Ltd., of London, W.C.2. Designated "Compactix 150", the apparatus, which is shockproof and rayproof, is in two main parts, i.e., the tube head and the control unit. The tube head, consisting of a cylindrical tank, contains the X-ray tube, a filament transformer, and a high-tension transformer. Electrical leads from the tube head to the control desk are restricted to mains tension connections. Because of its small overall dimensions (40 in. in length by 14½ in. in diameter) the tube head can be passed through narrow apertures previously inaccessible to X-ray inspection apparatus. The unit



is rated at 150 kVp, 10 mA, and the X-ray tube has a focal spot of 3 × 3 mm. The whole tube-head assembly is oil-immersed and water-cooled.

The controls consist of a kVp- or penetration selector, which is stepless from 50 to 150 kV; a milliampere selector, also stepless; a synchronous-motor exposure timer, 0 to 30 minutes; a mains-voltage compensator; a milliampere meter; a kilovolt meter; indicator lamps showing "no water flowing" and "high tension on", and mains and high-tension "on" and "off" push-buttons.

A number of alternative mountings is available for the tube head, which can be slung either vertically or horizontally from a hoist or crane; alternatively, it can be mounted on a mobile trolley, as shown in the illustration.

PORTABLE GEAR-PROFILE MEASURING INSTRUMENT

Designed primarily for use on large-diameter gears, ranging from 18 in. to over 16 ft in diameter, where accuracy of profile has to be maintained within extremely fine limits, a compact, portable gear-profile measuring instrument is announced by The David Brown Tool Division, of Huddersfield. The instrument (Fig. 1), which is equally suitable for the testing of spur or helical gears, is mounted on the gear by three spherical locators, six sets of which, ranging from $\frac{5}{16}$ to $\frac{3}{4}$ in. in diameter, are supplied with each instrument, to accommodate gears of various pitches. Horizontal and vertical slides are traversed by micrometer screws and can be set in any desired position to within 0·0001 in. The vertical slide carries a spherical-ended stylus, which operates a sensitive dial indicator, graduated in ten-thousandths.

The method employed to check the accuracy of the gear profile is based on the measurement of a series of predetermined horizontal and vertical coordinates, as

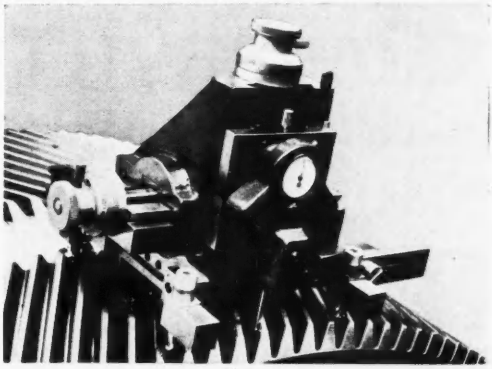


Fig. 1.

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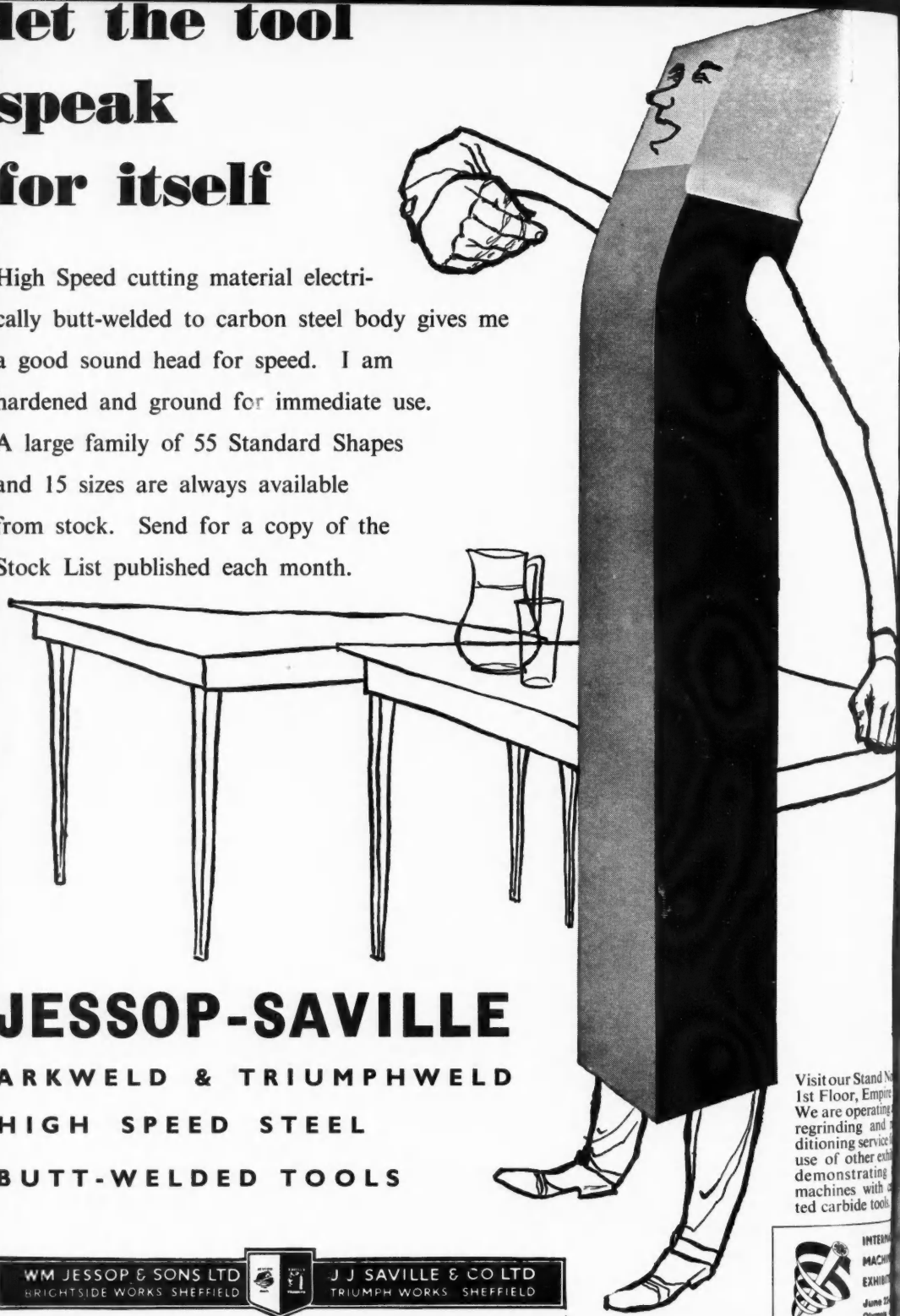

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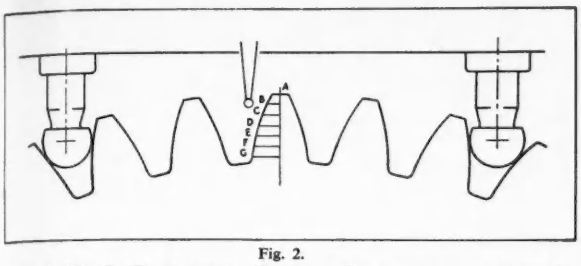


Fig. 2.

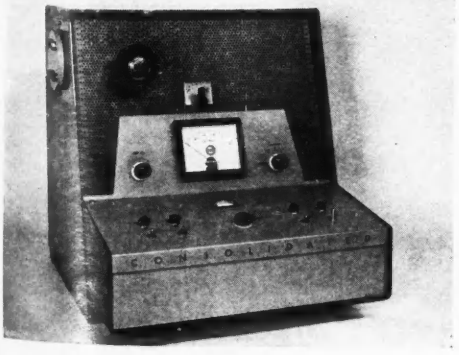
shown in Fig. 2. To commence the measuring sequence, the spherical-ended stylus is brought into contact with the outside diameter of the gear at point *A*, and the vertical thimble is set to zero. Next, the stylus is moved into the tooth space and then in a downward direction the distance of the first vertical coordinate plus the radius of the stylus sphere. The horizontal slide is then moved to enable the stylus to contact the flank at point *B*, following which the horizontal thimble and dial indicator are set to zero. As the next step the stylus is withdrawn into the space and moved downwards the distance of the second vertical coordinate, and the horizontal slide is traversed until the stylus contacts the flank at point *C* and the dial indicator shows zero reading; the reading on the horizontal thimble will then show any error that may be present at this point on the flank.

This operation is repeated down the flank at the predetermined vertical coordinates *D*, *E*, *F*, and *G*, thus making apparent the actual profile of the gear being checked.

PORTABLE LEAK DETECTOR FOR PRODUCTION-LINE TESTING

A new portable leak detector capable of the most exacting tests of either evacuated or pressurized systems is announced by the Consolidated Electrodynamics Corporation, of Pasadena, California. The instrument, designated Type 24–210, combines low cost with high sensitivity, and may be employed to show the existence or absence of extremely minute leaks, to determine the rate of leakage, and to pinpoint the exact location of a leak.

The instrument is a simplified mass spectrometer which responds only to the presence of helium as a tracer gas. By probe or air-sampling methods, it will detect one part of helium in 300,000 parts of air. Applications include testing hermetically sealed parts, refrigeration units, high-vacuum systems, and drums and other containers. By applying good vacuum geometry and a new high-speed pump, the cold trap ordinarily used to remove condensable gases and the difficult and expensive handling of liquid nitrogen have been eliminated. All operating controls and electronic components are accessible from the front. General operating controls

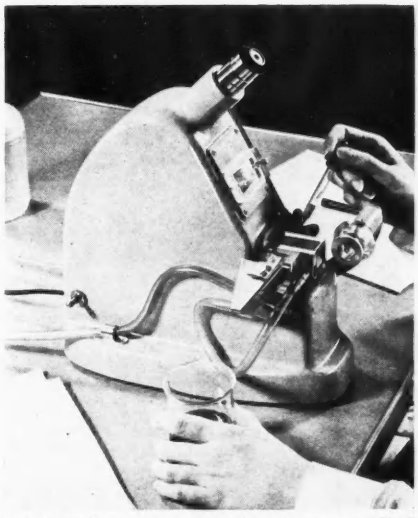


are located on the top front panel; the initial set-up controls are behind a protective panel directly below. Complete access to all electronic components is possible by lifting the hinged-top front panel.

An audio-alarm and a mobile workstand are two of several accessories available. The alarm gives an audible indication of leak rate, enabling the operator easily to tell when the sampling probe approaches or passes over a leak. The pitch of the signal varies with the amount of helium entering the leak detector, giving a quantitative estimate of leak rate. The volume and threshold of the alarm are adjustable. The mobile workstand is designed to carry the unit and to provide a small work area on each side. The stand includes a drawer and a lower shelf which can be used for mounting an auxiliary vacuum system.

REFRACTOMETER WITH SIMPLIFIED OPERATING PROCEDURES

As a result of the simple, fast operating procedures built into their new Abbé-3L refractometer by the Bausch & Lomb Optical Co., of Rochester, N.Y., an operator can, in one minute, load, light, and view through the instrument to obtain the refractive index of liquids, dissolved solids, and some opaque solids. The new instrument should therefore be particularly useful for quality control in the food, chemical, and petroleum industries, and for production-line applications, where it can be operated by non-technical personnel.



Loading the refractometer has been simplified by mounting the prism assembly in front of the operator within easy reach, and in a horizontal position to reduce spillage. The sample is lighted quickly with a built-on illuminator, which swings into position. Lamps can be easily changed and are of the readily-available flashlight type. Readings are taken with a single eyepiece from a convenient relaxed sitting position. Numbers are easy to read because of an internal illumination system. The refractive-index range is 1·30 to 1·71; the solids scale reads from 0 to 85%. The instrument requires little field servicing. For the first time, users can make complete calibration adjustments with an Allen wrench, which can be inserted through an opening in the instrument body and turned until the reading corresponds with that of a glass testpiece. Prisms can also be changed by the user.

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INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

In our May issue a preview was included of some of the items to be shown at the International Machine Tool Exhibition, to be held this year between 22nd June and 6th July. A further selection is included in the following pages.

An exceptionally wide range of machine tools and ancillary equipment is being exhibited by **Gaston E. Marbaix Ltd.**, of London, S.W.11. Of these, an interesting exhibit is the model TA-20-S automatic wire-measuring, cutting, stripping, and terminal-attaching machine manufactured by the Artos Engineering Company, of Milwaukee, Wisconsin. This machine (Fig. 24)—the first of its kind to be shown in Great Britain—automatically measures and cuts lead wire to a preset length, strips the insulation from one or both ends, and attaches a terminal to one of the stripped ends. The machine is furnished with two complete blade assemblies and one terminal-attaching die unit for one size and type of terminal, but the terminal-attaching unit can be made for any strip type of terminal, and additional terminal-attaching units can be provided. These units are readily interchangeable, so that the machine can be used to attach several types or sizes of terminals in strip form. After the original adjustment of the die unit has been made, it can be removed and reinstated at any time without further adjustment.

Another Artos machine exhibited is the Type CS-6E. This is already well known in Great Britain but, on the particular machine shown, a special wire-marking device is demonstrated for the first time. This device marks the wire at one or both ends, so that wires can be measured, cut, stripped, and marked.

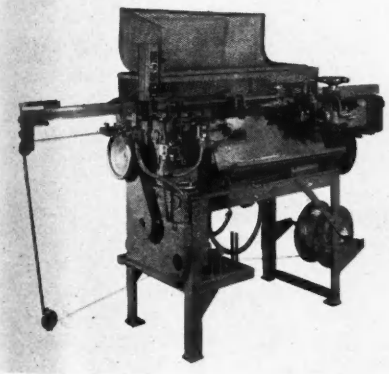


Fig. 24.

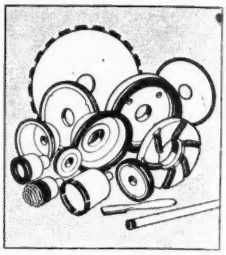
The Hartford model A-190-R automatic thread roller, manufactured by the Hartford Special Machinery Company, of Hartford, Connecticut, is also being exhibited by Marbaix. This machine (Fig. 25) has now been equipped with a newly designed rotary-type hopper, which increases the efficiency of the basic model by no less than 75%; as a result, production with this machine has increased to between 230 and 250 pieces per minute. The new rotary hopper has been designed for easy maintenance and repair. The bucket lifts out for servicing, without disturbing any previous setting. The clearing wheel is mounted on a bracket which swings away from the tracks for easy inspection and replacement. A self-contained motor drives the rotary hopper independently of the thread roller itself, making bucket speed variable merely by changing gears.

Fig. 25.

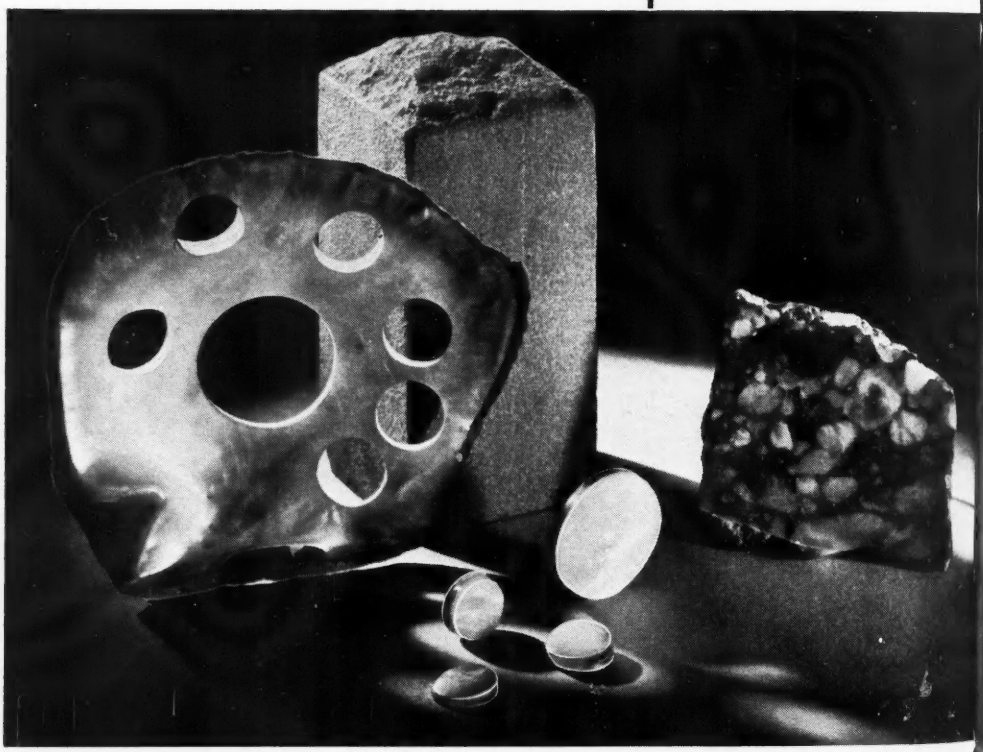
Other American equipment exhibited by Marbaix include a range of tapping, drilling, and angular burring machines from the Snow Manufacturing Company, of Bellwood, Illinois; a nut-slotting machine by the Pellow Machine Company, of Detroit, Michigan; a high-speed screw-slotting machine by the Grosite Manufacturing Company, Inc., of Hartford, Connecticut; and three automatic multi-presses manufactured by the Denison Engineering Company, of Columbus, Ohio. Of these, two are of 8 tons and 25 tons respectively, complete with multi-station index tables, while the third is the latest addition to the Denison range—a 1-ton midget multi-press, which answers the need for a lightweight, compact, high-speed press. This versatile unit, which is very simple to operate, is designed for installations which require up to 8 in. daylight and a pressing range between 400 and 2000 lb. The overall height is only 24 in., and the stroke of the press is 3 in. Based on a 1-in. stroke, 150 operating cycles per minute can be obtained.

Another interesting Marbaix exhibit is the "Barnes-driL" 224A British-built single-spindle honer with pneumatic sizing equipment of the signal-light type. This machine (Fig. 26) is a single-spindle, vertical, hydraulically operated honer with a 25-in. stroke, built under licence in Great Britain from the Barnes Drill Export Company, of Rockford, Illinois. Vickers hydraulic equipment is used throughout the machine, offering four quick-change geared speeds of 150, 245, 392, and 600 rpm. The head has an air counterbalance and the machine is equipped as standard with automatically controlled hone expan-

NEVEN *Diamond* TOOLS



cut, drill or grind any hard material



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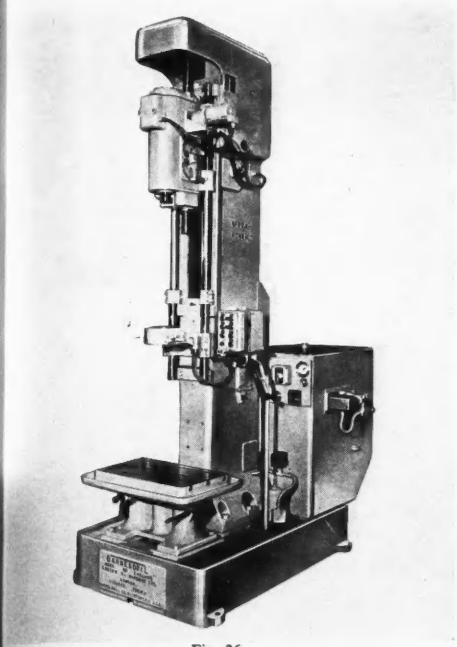


Fig. 26

sion, including automatic lift-out and remote-control wedge with electrically controlled rapid expansion. Positive depth stop and dwell mechanism is included, and the machine has a rectangular independent table with two raising screws with a finished surface of 17 × 28 in. area. The spindle is driven from a 5-hp motor, while the hydraulic circuit is powered from a 3-hp squirrel-cage motor. The machine is complete with the latest British-built "Kleenall" combination fabric and magnetic filter. The machine shown is fitted with "Plugmatic" sizing equipment of the signal-light type, giving an almost entirely automatic honing operation, the only attention required being an occasional adjustment for stone wear by the operator. The honing cycle is automatic and size is held from bore to bore to within very fine limits, a signal light indicating when the final size has been reached, when the hone withdraws, enabling the components to be changed at the fixture.

Representative of three sizes of machine built by Gebr. Mägerle, of Uster, Switzerland, is the F10 hydraulic surface grinder (Fig. 27), also exhibited by Marbaix. This machine, which has a longitudinal travel of 1000 mm and a cross traverse of 270 mm, incorporates, like the others in the range, automatic downfeed to the head, actuated either by reversal of the cross-slide or at the end of the longitudinal table cycle. This downfeed is infinitely variable between 0·001 and 0·0005 in., and an automatic final-size stop will repeat accurately to within 0·0002 in. In addition, a compensating dressing device in the head ensures that wheel wear by diamond dressing is automatically compensated in the final size. The head is powered for rapid traverse, either up or down, and a handwheel, fitted on the downfeed, is graduated in increments of 0·0001 in. The longitudinal table feed is infinitely variable between 10 and 100 fpm, and the cross-slide has both continuous and step feeds, both of which are adjustable through a wide range. A signal light indicates when the automatic downfeed is working and cuts out on reaching the final size. In addition, lights indicate the power supply to the machine and in particular register when the magnetic chuck is under power. This is controlled by built-in switchgear, which has two positions (magnetize and demagnetize) and neutral. Apart from the automatic feature of the machine, however, the latest developments shown include cross-feed measuring and locking devices, crush-dressing equipment for form-grinding work, a limit-stop attachment in the machine base, and coolant to the wheel. A speed-regulating set is fitted, enabling spindle speeds to be selected at will and allowing automatic compensation for reduction in wheel diameter. In particular, the crush-dressing arrangement is such that the crushing rolls are mounted above the head, permitting the retention of the automatic downfeed and compensating dressing features. This leaves an entirely free table area, since no space is taken up by work or reference rolls.

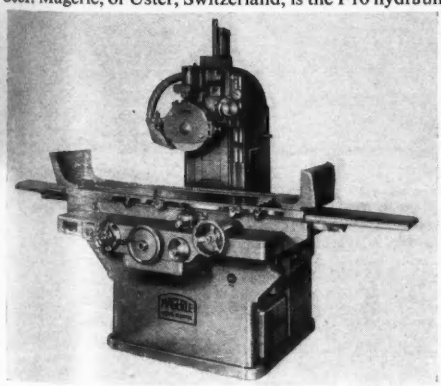
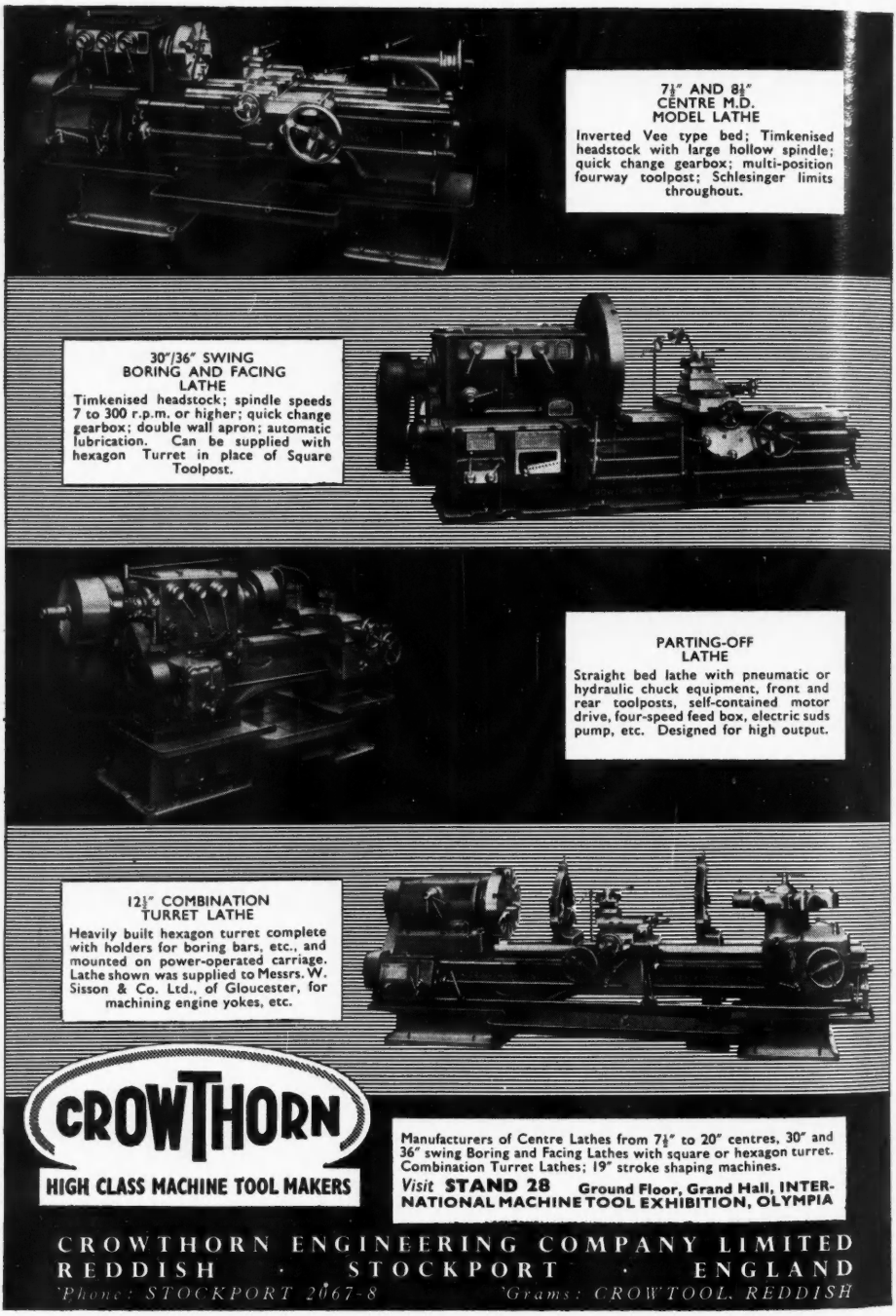


Fig. 27

Fig. 28

Another Swiss exhibit by Marbaix is the Kummer model MR-6020 twin-head semi-automatic contouring lathe, manufactured by Kummer Frères S.A., of Tramelan. With its twin-head construction, this machine (Fig. 28) is ideal for second-operation work, and can be considered virtually as two machines, inasmuch as it is symmetrical about the centre-line, each half being a reflection of the other. The heads are quite independent of one another and can be tooled for identical or for different operations. Each head has a forward stroke of 20 mm, and parts up to 55 mm o.d., or 60 mm i.d. can be machined. It is possible in certain cases to increase the diameter range. Each spindle is driven from a 1½-hp motor through speed variators to give a stepless spindle speed range. On each head two or three tools are held on a compound slide, each carriage being fed from cams.


7½" AND 8½"
CENTRE M.D.
MODEL LATHE
Inverted Vee type bed; Timkenised headstock with large hollow spindle; quick change gearbox; multi-position fourway toolpost; Schlesinger limits throughout.
30"/36" SWING
BORING AND FACING
LATHE
Timkenised headstock; spindle speeds 7 to 300 r.p.m. or higher; quick change gearbox; double wall apron; automatic lubrication. Can be supplied with hexagon Turret in place of Square Toolpost.
PARTING-OFF
LATHE
Straight bed lathe with pneumatic or hydraulic chuck equipment, front and rear toolposts, self-contained motor drive, four-speed feed box, electric suds pump, etc. Designed for high output.
12½" COMBINATION
TURRET LATHE
Heavily built hexagon turret complete with holders for boring bars, etc., and mounted on power-operated carriage. Lathe shown was supplied to Messrs. W. Sisson & Co. Ltd., of Gloucester, for machining engine yokes, etc.
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All forward movements of the tool carriers are positive, being taken from the cams through levers, while retraction is controlled by spring pressure. When turning diameters, four positive stops are available throughout the forward stroke of the machine; these can be set at will and are independent of the operation of the cams, thus ensuring very close control.

Finally, other Marbaix exhibits include a range of British-built Delta-Milwaukee air-hydraulic drill units on special-purpose machines; an Ekstrom Carlson "Vertimil" model 5V milling machine with swivel head and table; a range of Gisholt superfinishing machines; a Stutzman shaving press, model SM3; a Marbaix servo-feed disintegrator; and a wide range of optical and micrometrical equipment, including Kodak optical inspection equipment, contour projectors, and gear analysers, and surface measuring equipment.

Among the extensive range of new equipment exhibited by **The Churchill Machine Tool Co. Ltd.**, of Broadheath, near Manchester, an entirely new item is the model HBM automatic-sizing internal grinding machine, illustrated in Fig. 29. This machine can be operated on a double automatic cycle with intermediate

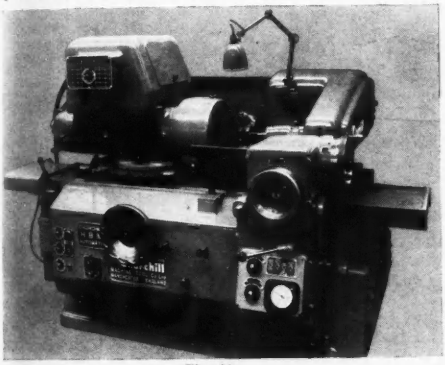

Fig. 29

truing, in addition to a single automatic cycle, the choice being determined by the work to be ground. In either case sizing is controlled by the setting of the wheel-truing diamond, but the essential difference between the two cycles is in wheel truing, which in the single cycle occurs just prior to the grinding wheel entering the bore of the work, whereas in the double cycle it takes place between roughing and finishing stages. The change-over from the double to the single cycle and vice versa is easily and quickly made. The feed is applied by cross adjustment of the grinding-wheel spindle slide, the work being reciprocated longitudinally, or when plunge-grinding held stationary, in relation to the grinding wheel. When required, work-oscillating mechanism can be incorporated, a feature fitted to the machine exhibited. The cross-slide carrying the grinding-wheel spindle is mounted on rollers to ensure the most sensitive feed movement. The cross-feed to the grinding wheel is continuous and operates by means of a cam mechanism which gives a constantly diminishing rate of feed, starting at the maximum when the wheel enters the bore of the work, and gradually decreasing to zero as the bore reaches size. The principle of a single-revolution cam is used, so that each grinding cycle is completed for every revolution of the cam. The camshaft is driven by a variable-speed motor and, in conjunction with pick-off gears in the drive, a wide range of feed cycle times is made available to cover all possible work requirements. Roughing and finishing feeds can be selected independently and, after being preset, the change from roughing to finishing becomes automatic. An electrically controlled dwell at sizing position is a feature of particular advantage in obtaining accurate sizing and in building up high finish. The dwell period, which is preset, is visible on the dial of a timing unit on the front of the feed-control panel.

A feature of the model HBM machine is the "feed accelerator", by means of which the rate of feed is automatically increased to provide the wheel with a quick approach until it commences to cut. The cycle time is therefore reduced, should the grinding tolerance be less than that for which the feed is set. The single automatic cycle commences when the starting lever is operated, the work-table moving in at fast speed towards the grinding wheel. When the truing device, which is mounted on the work-table immediately in front of the work, reaches the grinding wheel, the work-table slows down to truing speed, the diamond moves down automatically into position, and the wheel is dressed. The table then speeds up until the grinding wheel enters the bore of the work. At this stage the work-table commences to reciprocate at grinding speed, the cross-feed movement operates, and both continue until the finished size is reached. The grinding wheel then drops back from the work and the work-table runs out at fast speed to the rest position for unloading. In the double-automatic cycle, operation of the starting lever causes the work-table to move in at a fast speed until the grinding wheel enters the bore. The traverse then slows down to grinding speed, and the work-table reciprocates on a stroke sufficient to cover the full length of the bore. At this stage the cross-feed of the wheel commences, and both movements continue until roughing size is reached. The grinding wheel then drops back from the work, and the work-table retracts until the rear edge of the wheel is just clear of the diamond position. The work-table then slows down to truing speed, the diamond moves into truing position, and the wheel is dressed. As the diamond reaches the front edge of the wheel, the work-table reverses and the diamond dresses the wheel in the reverse direction. Immediately the diamond passes the rear edge of the wheel, the diamond retracts, the work-table reverses, and the traverse speed is increased until the grinding wheel again enters the bore. Reciprocation of the work and the cross-feed of the wheel then recommence. When finished size in the bore is reached the automatic dwell comes into operation, at the completion of which the work-table runs out at a fast speed to the stop position for work unloading. In plunge-grinding the automatic cycle operates similarly, except that the work-table remains stationary when the wheel enters the bore, or it can be oscillated slightly, as determined by the nature of the work.

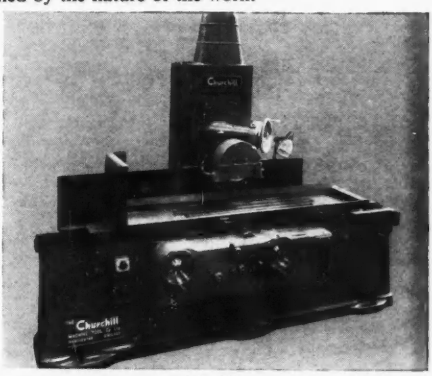

Fig. 30

Whilst the model HBM is basically a fully automatic sizing machine, consideration has been given in the design to meet the needs of users requiring the advantages of an automatic machine with facilitities to deal economically with short runs, or even single components. This machine fully meets such requirements. A hand feed wheel with micrometer adjustment and suitable dead

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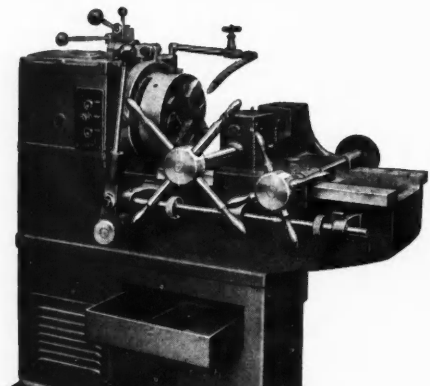

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Maximum capacity for bolts ... ... 1 in.
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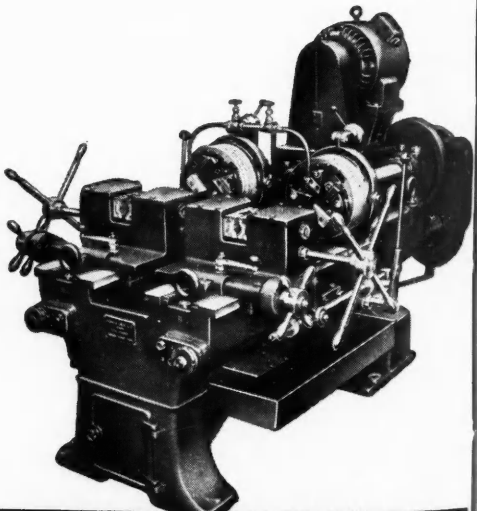

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stops can be brought into use, enabling the machine to be used as a non-automatic plain internal grinder.

Another entirely new Churchill exhibit is the model OSB 42 × 10 in. horizontal surface-grinding machine (Fig. 30), intended for work requiring an extremely accurate and highly finished flat surface, grinding being carried out with the periphery of the wheel mounted on a horizontal spindle. This machine will accommodate grinding wheels up to 4 in. in width, thus making it easily adaptable for form-grinding, using either the crushed-wheel or diamond-forming method. It is especially well-suited for die-grinding and similar work. The table traverse is hydraulically variable, and any speed, up to 90 fpm, can be obtained instantly. Hand traverse is also fitted and is interlocked with the hydraulic control, so that both cannot be engaged simultaneously. The table slideways are very long and the overhang of the table at the extreme positions of the stroke is negligible. A built-in motor drive to the grinding-wheel spindle is a feature of the machine. Cross movement of the wheel-head carriage is operated by an auxiliary hydraulic mechanism, and can be adjusted to give from 0·010 to 0·150 in. movement at each traverse stroke, the maximum cross movement being 10 in. Provision is made for the cross-feed to be cut out automatically at a predetermined position, and automatic reverse can be introduced as an alternative to the automatic cut-out, as required. The cross traverse can also be operated independently by hand, with separate coarse and fine movements. The maximum height admitted between the table and the full-size grinding wheel is 16 in.

Other Churchill exhibits include their model PAW 10 × 24 in. universal grinding machine; their model BW 10 × 36 in. automatic-sizing plain grinding machine, with hydraulic diminishing feed and automatic sizing cycle; their model AW 6 × 18 in. fulcro-sizer fully automatic plain grinding machine, in which the wheel-head slide is set at a definite position, where it remains throughout the grinding operation, feed being applied by tilting the table carrying the work towards the grinding wheel; their model OSD 48 × 12 in. open-side surface grinding machine, which is a new heavy-duty horizontal-spindle machine, exhibited for the first time; their model NB 18 × 6 in. horizontal-spindle surface grinder, which is a small-capacity grinder capable of producing an extremely accurate and high surface finish; and their model G 60 × 312 in. heavy plain grinding machine, which, though a large-capacity unit of essentially heavy dimensions, incorporates all the design features necessary to ensure sensitive control and ease of operation.

Among a wide range of milling machines exhibited by **Adcock & Shipley Ltd.**, of Leicester, an interesting newcomer, not previously shown, is the model 4HG heavy-duty horizontal milling machine (Fig. 31). Based largely on their model 4AG machines, this latest model is fitted with a 25-hp motor and is suitable for use with tungsten carbide cutters with positive, zero, or negative rakes. Features include infinitely variable feed, ranging from ½ to 64 ipm; a positive backlash eliminator; a special spindle-drive attachment, ensuring that every drive gear is larger than the cutter it will drive; five spindle bearings, with a flywheel effect, located directly behind the front bearing unit, as close as possible to the cutter; a built-in ammeter and speed and feed calculator; and duplication of controls, with hand adjustments and locks at the front and the rear of the knee, which is of new design, incorporating a bearing surface, 24 in. in width, for the cross-slide, automatic lubrication to the lead-screws and slides, and a heavier column. This machine can be supplied as a plain or universal model, and can be equipped with a universal milling attachment, a vertical milling attachment swivelling in one plane, or a fixed heavy-duty vertical milling attachment capable of transmitting the full power of the main drive motor.

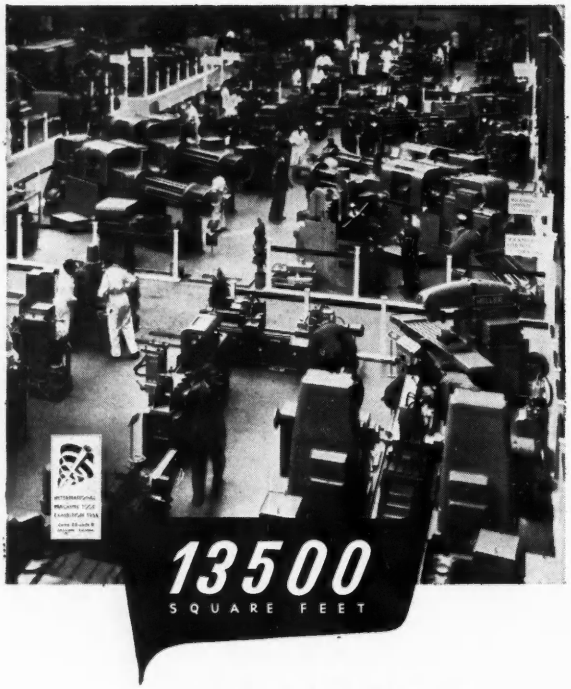
Other Adcock & Shipley horizontal milling machines exhibited include the 3HG machine, of similar design to the 4HG just described, but of smaller dimensions and fitted with a 15-hp motor; the 2AG horizontal miller, which is eminently suitable for small-quantity, batch-production, or toolroom work; and representative examples from their wide range of Size 0 and Size 1 machines. In addition, a number of their vertical milling machines will be exhibited, including examples from their Size 0, Size 1, and Size 2 models.

Fig. 31

Another interesting Adcock & Shipley exhibit is their model No. 2JUR universal milling machine. This machine, which has not been previously exhibited, is the smallest in the company's range giving rapid traverse in all directions. The table size is 50 × 10 in., and each machine is equipped with a positive backlash eliminator and fitted with push-button lubrication to all slides. This model can also be supplied as a plain machine with rapid traverse in all directions.

Other items in the Adcock & Shipley range of exhibits include their model 2VR continuous milling machine, which is a new model, fitted with a No. 40 taper spindle and driven by a 3-hp, four-speed motor, which, in conjunction with a back gear, gives eight spindle speeds; their SV40A radial drilling machine—a 36-in. model, with a 1-in. capacity in mild steel; and their Size No. 2 rotary transfer machine, which is being shown with a four-station, automatic indexing table arranged for boring automobile components. This machine can, however, be arranged with a hand-indexing table, with a different number of stations for drilling, boring, reaming, facing, and tapping operations.

Of the ten machines exhibited by **David Brown Industries Ltd., Machine Tool Division,** of Manchester, seven are completely new. Of these, one of the most interesting exhibits is the new No. 7 "Hydrax" production gear hobber (Fig. 32), a smaller edition of the highly successful No. 14 "Hydrax", claimed to be the world's fastest machine of its type. Features common to both the No. 7 and No. 14 models are a hydraulically operated work clamp; a fully automatic cutting cycle; no differential or lead cam; and automatic loading and exceptionally high production rates. Hob traverse on both these machines is along the gear helix. In the case of the No. 7 "Hydrax", however, the hob traverse is inclined at the spiral angle of the horizontally mounted work, whereas, in the case of the No. 14 machine, the



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Wickman exhibit

The Wickman exhibit at this year's International Machine Tool Exhibition will be the largest ever presented by the Company.

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Wickman Optical Profile Grinding Machines.
Wickman Erodomatics.

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National Hall
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Collet & Engelhard Horizontal Boring Machines.
Duchscher-Wecker Hammering Machines.
Eumuco Forging Equipment.
Heller Milling Machines.
Herlan Extrusion Presses.
Klopp Shaping Machines.
Kopp Profile Milling Machines.
Lorenz Gear Shaping & Hobbing Machines.
Maypres Toggle Presses.
Nagel Honing Equipment.
Naxos-Union Grinding Machines.
Pines Tube Benders.
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Weingarten Presses.
Weipert Lathes.
Wickman-Moulton Thread Milling Machines.

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National Hall
Davenport Multi-spindle Automatics.
Warner & Swasey Chucking Lathes.

STAND 110
National Hall
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STAND 318
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Wickman Tool Grinding Equipment.
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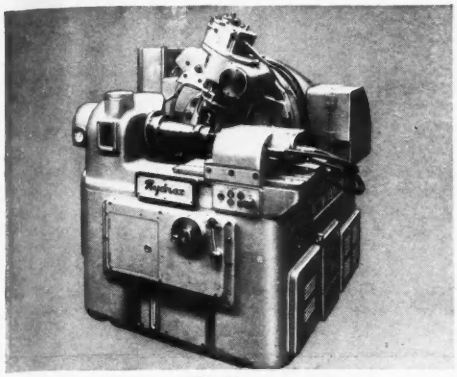

Fig. 32.

gear helix is set in the vertical plane. Maximum gear capacities are 7 in. diameter and 4¾ in. face-width for the No. 7, and 13½ in. diameter and 9¼ in. face-width for the No. 14 " Hydrax ".

Other interesting David Brown exhibits are the new S6H and S12 production gear-shaving machines, the principal characteristics of which are fully automatic operation and loading, combined with high-speed production. Designed for the rapid shaving of spur and helical gears up to 6½ and 12 in. gear diameter respectively, by the radial-loading method, both these machines employ the crossed-axis principle and are capable of applying any of three different types of shaving technique, i.e., axial traverse, oblique traverse, or tangential traverse. Model S6H is illustrated in Fig. 33.

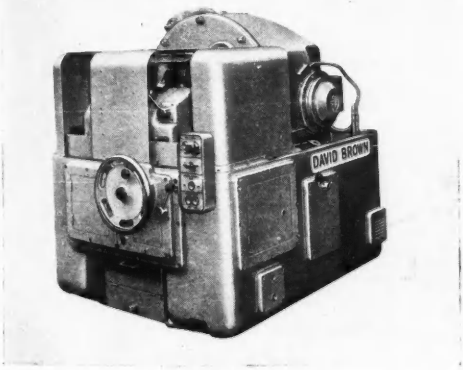

Fig. 33.

The largest of the new machines exhibited by David Brown is their PH30 production gear hobber (Fig. 34), which has a maximum gear capacity of 30 in. diameter, 16 in. face-width, and 1 in. circular pitch. This moving-table machine is capable of the rapid production, singly or in batches, of spur and helical gears, worm wheels, and also sprockets and spline shafts. A notable feature is that, after the work has been set, the bed and work-slide, stay and overarm, and steady-bearing and stay are rigidly clamped together by hydraulic means. In addition, the machine can be supplied with an automatic cycle, whereby plunge and longitudinal feeds are controlled by a single push-button.

Finally, a new range of spiral bevel and hypoid gear generating machines, of a type hitherto obtainable only in the U.S.A., has been developed by the company, and examples from this new range are exhibited. These are the B17 testing machine, designed for spiral bevel and hypoid gears up to 20 in. in diameter; the B11 roughing

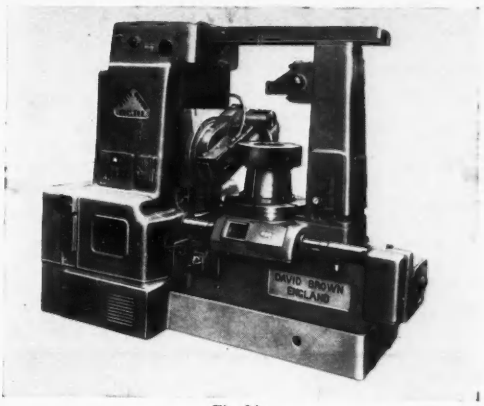

Fig. 34.

machine for gears up to 13 in. in diameter, 3·5 D.P.; and the B16 generating machine for gears up to 18 in. in diameter, 2·5 D.P.

The widest possible range of marking machines adaptable to any marking application on metal, glass, wood, plastic, etc., and showing the diverse methods applied to obtain permanent marking at speeds consistent with modern production, is being exhibited by **Funditor Limited,** of London, E.C.1. These machines include heavy-duty hydraulic and pneumatic-hydraulic marking machines, light-duty bar-marking machines, sand-jet marking machines, and a horizontal hydraulic flywheel- and flange-marking machine (Fig. 35). This latter machine has been developed specifically for the automatic marking of graduations on flywheels, e.g., for adjusting engine timing, but, with slight modifications, it can be used for marking flanges for water, steam, and oil pipe-lines. The standard machine will graduate or mark flywheels and flanges from 12 to 18 in. in diameter, with production rates of from 100 to 250 per hour.

Other Funditor marking machines shown include a handlever-operated bench machine for small components ; a treadle machine, with hand and foot operation ; a pneumatic machine with a pneumatically operated table ; a tag-embossing machine for light-gauge metal shipping tags or specification tags on material ; an electric metal-marking typewriter for deep-marking metal nameplates and instruction plates ; and a tape-embossing machine for embossing from 1 to 10 lines of letters and figures into coils of metal, punching and cutting off into labels.

In addition, Funditor will exhibit representative

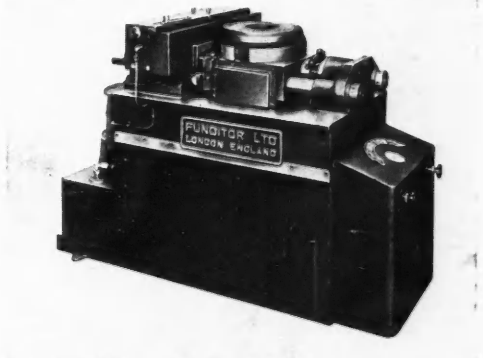

Fig. 35.

The Gloster JAVELIN
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Churchill

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models from their wide range of electric ovens, which are suitable for preheating, drying, baking, and numerous other heat-treatment processes. A range of metal-melting equipment will also be shown, including their model T.M.2 tilting furnace, which is equipped with a geared tilting mechanism, ensuring positive control of pouring.

Among the exhibits by **Hardinge Machine Tools Limited**, of Hanworth, Middlesex, a member of the **Sheepbridge Engineering Group**, is an interesting copying attachment for the Hardinge HLV Lathe.

This attachment, which was developed by Hardinge in conjunction with **Hayes Engineering (Leeds) Limited**, has a number of outstanding features. Thus, for example, it can remain in position on the lathe, without interfering with normal turning operations, and it incorporates a control for taking successive rough cuts. Furthermore, holders for both circular masters and templates are provided, together with longitudinal adjustment of the former holder. Finally, this attachment provides extreme accuracy of duplication.

One of the principal items to be exhibited by **Thomas White & Sons Ltd**, of Paisley, Scotland, will be a cartridge gauging and weighing machine (Fig. 36). Primarily designed for checking finished rounds of small-arms ammunition, its principle can, however, be simply applied to the gauging of other similar-sized components. The machine consists essentially of a hopper, three gauging stations, and one weighing station. The cartridges are placed in the hopper by hand, but afterwards the transfer between gauging and weighing stations is carried out mechanically. The rate of checking is 50 rounds per minute. The hopper feeds the cartridges in such a way as to ensure that there is no possibility of the bullet of one cartridge striking the cap of another. From the hopper the cartridges are passed, by rotating circular carriers and transfer fingers, from one gauging station to the next, those which are rejected falling into appropriately marked containers. A sealed counting device is fitted, and this records the number of cartridges passed as satisfactory. The gauging units can be readily adjusted to suit the required high and low limits, and the rotating-beam weighing unit measures to $\pm$ 1 grain. The machine is driven by a $\frac{1}{4}$-hp motor through a clutch which slips in the event of an obstruction. A separate $\frac{1}{4}$-hp motor drives the hopper through a worm reduction unit. All working parts are enclosed in a glass case, excluding dirt and dust, but giving a clear view of the operation.

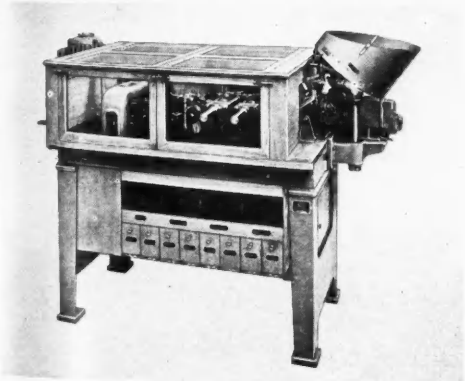

Fig. 36.

The Company will also be exhibiting a selection of their well-known woodworking machinery, including their Type 444 12 × 4 in. planing and moulding machine, which has been redesigned, and their Type M.P. automatic double-spindle shaper, which is the only machine of its kind manufactured in Great Britain, enabling the operator to load one jig while the other is in use. Feed speeds in this machine, which is basically similar to a hand-fed spindle moulder or shaper but has a power-operated jig-feed attachment, are infinitely variable between 13 and 30 fpm.

Other White exhibits will include their 36-in. double-drum sander, in which the abrasive paper is mounted spirally on the drums and in which a floating conveyor unit is used ; their Type GA/A automatic plane-iron grinding machine, which is intended for the " dry " grinding of planing knives up to 36 in. in length, though it can also be supplied for " wet " grinding, while attachments can be fitted for gulleting saws, for sharpening solid profile cutters, and for grinding moulding irons ; and their " Trufeed " straight-line rip-saw and edger, Type SJB, the principal feature of which is its hydraulic feed gear, which enables any feed speed from 0 to 200 fpm to be selected.

An interesting new machine exhibited by **Wm. Asquith Ltd.**, of Halifax, is their 10-in. ram-type horizontal milling and boring machine (Fig. 37). In this machine, the slide is of heavy proportions and carries a ram of rectangular section, arranged to house the milling sleeve and spindle. The front of the ram is provided with a facing, to which can be bolted various types of milling attachments, driven by the milling sleeve or spindle. The

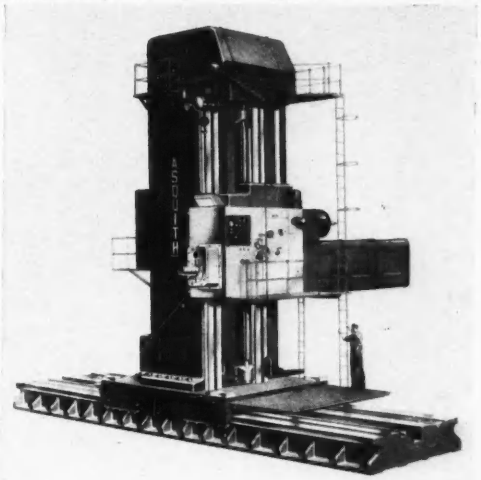

Fig. 37.

flange at the front end of the milling sleeve is designed to carry milling cutters, if desired, and a surfacing slide attachment can also be fitted to the flange. When this is applied, provision is made to obtain feed changes and full control of the slide, giving the facilities of a built-in facing slide. The spindle is driven from the milling sleeve, and both the spindle and ram have feed and rapid power-traverse motions, the latter by means of one common motor, while feed motion is obtained by gearing in the slide. Micro-setting is applied to the spindle and ram movements, and is operated by one common motor. Milling feeds and rapid power traverse vertically are supplied to the slide and are operated by separate motors. The main driving motor is mounted upon the slide and this, in conjunction with speed changes in the slide, gives an infinitely variable range. The milling feed range is also infinitely variable, and the motors are controlled by Ward-Leonard equipment. The slide is balanced by a weight suspended in the column.

The column is of wide section, to carry the slide, and of proportions to meet heavy milling operations. The column is bolted to a base which has feed and rapid

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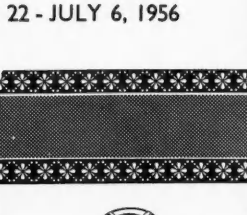

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power traverse along the bed, and also micro-setting, each being operated by separate motors in a similar manner to the slide. The bed is of very wide section, again designed with the object of obtaining a very rigid condition for heavy milling operations. Rules and verniers are fitted to all traverses, and optical gear is provided for readings. This gear comprises telescopes, prisms, and mirrors, where necessary, and all readings are made from a forward position on the slide. The main control panel for the operation of the machine is on the slide, and carries the necessary push-buttons and dials for all motions, including controls for speed and feed variations and for steering. A pendent control is also fitted and carries push-button controls for the main motor, for the traverse motors for the ram and spindle, and for the control of the feed to the ram and spindle, for which an electrically operated clutch is incorporated in the feed system.

As is only to be expected, the wide range of machines exhibited by the **600 Group**, of London, N.W.10, is representative not only of those actually manufactured by companies within the Group itself, but also of those British, American, and Continental machines for which the Group act as distributors in the United Kingdom.

Of these companies within the 600 Group, **George Cohen Sons & Co.** feature a range of " Imperia " carbide-tool grinders and tool and cutter grinders; GSP shaping machines and drilling machines; Jasper universal and vertical milling machines; Demoor lathes; Gambin milling machines; and Pegard universal boring machines. In this connection, the Pegard universal horizontal boring machine, model U100 TA, is a new French development, never exhibited previously, most important among its new features being the greatly increased rigidity afforded by the use of four slideways. As a result, this versatile machine is able to perform milling, boring, turning, reaming, and tapping operations on very heavy workpieces. Eighteen spindle speeds are provided, ranging from 7 to 1400 rpm, the higher speeds permitting the use of carbide tools. Feed selection is automatic and is determined by the cutting speed. Other features include synchronization of the boring stay with the rise and fall of the spindle, reduced overhang of the head, and a safety overload clutch device.

Of the Gambin milling machines mentioned above, manufactured by Gambin-Cie, of Boulogne-Billancourt, an interesting newcomer is the Gambin model 2N, with a table surface of approximately 47½ × 11¾ in., and a longitudinal travel of about 27½ in. The main feature of this French machine (Fig. 38), which has been designed for shops requiring a simple machine capable of carrying out a wide range of machining operations, yet which is easy to set up and to operate, is the milling head, which is of particularly rugged construction and is mounted in a bore in the rigid frame. In addition to its great strength, it is designed to permit accurate positioning of the spindle with the aid of a single, direct scale.

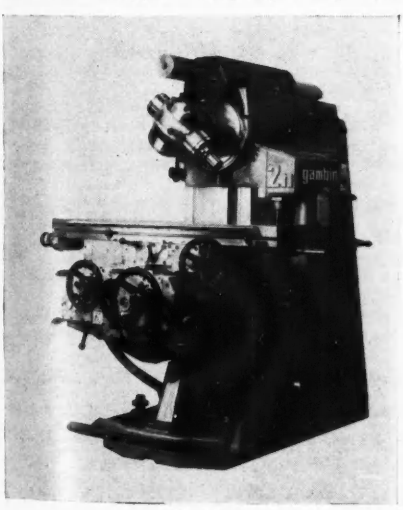

Fig. 38.

Exhibits from the **Selson Machine Tool Co. Ltd.**, another member of the 600 Group, include a new Cleveland " Dialmatic " single-spindle automatic, model AB, of 1⅜ in. capacity (Fig. 39). This machine, manufactured by the Cleveland Automatic Machine Co., of Cincinnati, Ohio, represents a considerable advance over the earlier 3-in. " Dialmatic ", inasmuch as, while electronic control in the 3-in. machines applied only to the turret tool feeds, in the new 1⅜-in. model both turret feed and spindle speed are infinitely variable through the range. The optimum cutting speed for each of the ten possible operations in the machining cycle can be preset on the dials (there are no cam or gear changes to be made) and adjustments to any speed can be made during actual operation. As a result, setting-up is greatly simplified and speeded up.

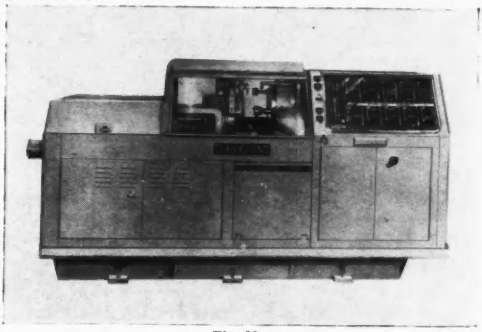

Fig. 39.

Also exhibited by the Selson Machine Tool Co. Ltd. is a versatile new American machine, the Morey extra-heavy-duty vertical a rframe profile and milling machine. This interesting machine has been specially developed to meet the need for plant capable of machining the plates and forgings from which modern aircraft skins are built up and which must be accurately milled to fit the airframe spars. A wide range of spindle speeds gives considerable versatility to this new miller, enabling it to be used on aluminium and other non-ferrous materials, including plastics, as well as on ferrous metals with the lower speed ranges. Both carbide and high-speed steel tools can be used. An outstanding feature is the unusual simplicity of control. Dials, gauges, etc. have been dispensed with, operation being controlled merely by manipulation of three handwheels. Furthermore, although an attractively high working speed has been achieved, this has not been at the expense of accuracy, and tolerances as close as 0·002 in. can easily be maintained on rapid hand operation.

One of the largest machines exhibited by the Selson Machine Tool Co. Ltd. is the Skoda model HVF.160D bedplate-type horizontal boring and milling machine, manufactured by Skoda, of Prague, Czechoslovakia. This newly designed, heavy-duty machine, which has a boring capacity of 39 in., is capable of dealing with drilling, boring, reaming, milling, and screwcutting operations on large and heavy workpieces, these being clamped to a plate which is separate from the machine proper. A wide range of spindle speeds is provided, and spindle and face-plate drives are independent, permitting the most varied combination of arrangements, while all drive and feed shafts are carried in special anti-friction

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bearings. Other features include the provision of a speed indicator for both spindle and face-plate, and a small axial movement in the face-plate slide to allow for adjustment of the tool in the cut when a milling cutter is fitted to the face-plate.

Other exhibits from the Selson Machine Tool Co. Ltd. include a Gauthier precision automatic, model GM12, and a precision gear-hobbing machine, model W.1; a range of Hilgers semi-automatic and automatic cold tube-bending machines; Kollman milling machines; a Malcus centreless grinding machine, model MC-5; an Oliver No. 2 arc-face mill grinding machine; a range of Prahoma surface grinding machines; two Somua horizontal milling machines; a Stuhlmann internal key-seating machine, model NZ.250; a Trojan universal oil-grooving machine; a range of Kamenicek universal grinding machines and tool and cutter grinders; a Plauert horizontal boring, drilling, milling, and facing machine, model H.80; and a range of Zbrojovka universal, horizontal, and vertical milling machines.

Of the other companies in the 600 Group, **Midgley & Sutcliffe Ltd.** are exhibiting a range of Richmond radial drilling machines and milling machines, while **The Colchester Lathe Co.** feature their " Student " lathes, " Triumph Puma " and " Triumph Lion " lathes, " Mascot " lathes, and " Chipmaster " lathes.

The Maxicut " Maxirapid " high-speed, heavy-duty multi-tool lathe, exhibited by **Drummond Bros. Ltd.**, of Guildford, is a further development of the well-known " Maximatic ", and is a completely new design intended to meet the requirements of the automotive and other high-production industries. This machine (Fig. 40), which is powerful and of heavy and robust construction, is designed to use tungsten carbide tools to their utmost capacity. Chip clearance and disposal have been studied to the greatest possible degree, owing to the heavy metal-removal rate of which the machine is capable, so that the design of the angular bed permits chips to drop away to the base of the machine, from which they are removed by an automatic chip conveyor. The angular design of the bed also permits good facilities for the application of automatic handling of the workpiece in and out of the machine, and also the fitting of automatic gauging and chucking. Hydraulic units can also be mounted within the machine area for operating chucks, tailstocks, and other loading devices. The electrical control gear is also mounted on the machine at eye-level for easy access.

The headstock is of very rigid construction, the main spindle running on double precision taper roller bearings, and all shafts mounted on ball or roller bearings. The drive is by a constantly running motor mounted on top of the bed. Change-speed is obtained by pick-off gears, a high- and low-speed range being obtainable by hand operation of a sliding gear. Automatic two- or three-speed change, operated by electric clutches, can be fitted as an extra. Lubrication is by a separate gear pump, the headstock running on the dry-sump principle. The tailstock is hydraulically operated from the unit on the machine, the revolving spindle being mounted in double precision taper roller bearings at the front, and parallel roller bearings on the rear. The arrangement is such that there is no end thrust on the tailstock-spindle front bearing, whatever the loading. The tailstock is adjustable to any position along the bed. The saddle is operated along the bedways by a leadscrew driven from the feed-box unit at the headstock end of the machine. The cross-slide is bolted to the saddle and is operated by a flat former plate cam. Separate micrometer adjustment is provided for accurate tool setting. The cross-slide can be fixed in any position on the saddle, and two cross-slides can be fitted, when necessary. All wearing surfaces on the cross-slide are hardened and ground, and lubrication for both saddle and cross-slide is automatic from the central lubrication system. The rear slide is mounted on the top rear shear of the bed and is adjustable to any position along the bed. Two rear slides can be fitted, if required.

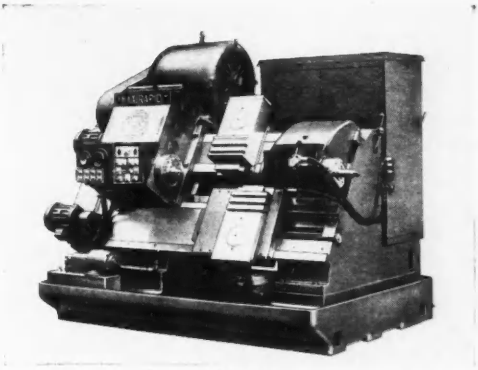

Fig. 40

A feed control box is fitted at the headstock end of the machine. It controls all motions to the front saddle, cross-slide, and rear slide. Rapid traverse is by an electric motor directly to the leadscrews. Feed traverse is by a chain drive from the main spindle through pick-off change gears and electromagnetic clutches on the leadscrews. Rapid traverse and feed motions are controlled by limit switches operated by dogs on revolving cam drums, and the units for operating the front and rear slides are entirely independent of each other. Easy access for setting dogs on drums and changing feed gears is provided.

The comprehensive range of exhibits from **Wild-Barfield Electric Furnaces Limited**, of Watford, Herts., will include a number of furnaces and high-frequency induction-heating equipment, some of which will be shown operating on a production basis. Also in operation will be a shaker-hearth furnace for the continuous carbonitriding of small components, and a complete drip-feed gas carburizing installation using the " Carbodrip " system.

Other exhibits from Wild-Barfield will include a horizontal batch-type production furnace, with a chamber 56 in. in length by 36 in. in width, and fitted with " tubular hairpin " elements. This furnace, which is designed for operation up to a maximum temperature of 2100°F, is built to withstand the hardest usage normally encountered in a heat-treatment shop. To complete the furnace equipment on the stand, a small self-contained electrode salt bath will be shown. This model, ESB 69, has a refractory pot for treatments at the more elevated temperatures with a diameter of 6 in. and a depth of 9 in.; for lower-temperature treatments and cyaniding a metal pot of larger dimensions is available. Interchanging of pots is a simple operation.

The Wild-Barfield AHF section of the stand will show a range of high-frequency generators for induction heating. Two models will be in operation, the 25-kW unit in conjunction with a progressive hardening unit, and a 7½-kW model on a small production application. The new 40-kW type will also be exhibited. This equipment has been designed to be economical in floor space and, despite its output, occupies an area no greater than that taken by a 15-kW model. A further example of induction heating will be exemplified by a small mains-frequency billet heater. This equipment is designed to illustrate the general construction of such units and is being shown in operation heating light-alloy billets 2 in. in diameter.

Many examples from the range of electrical equipment manufactured by **The British Thomson-Houston Co. Ltd.**, of Rugby, for the machine-tool industry will be exhibited, including stator and rotor units (for building in), electric motors, and control gear. In addition, B.T.H. electrical

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equipment will be seen in operation on the stands of no less than 24 machine-tool manufacturers.

Furthermore, representative of the range of automatic electronic control systems developed by B.T.H. in collaboration with machine-tool manufacturers, exhibits of such control systems will include automatic co-ordinate setting, primarily for boring operations, on a Newall, type ALZ-2442 jig borer, and on a Kearns, type OPT, horizontal boring machine (as described in our issue of April, 1956). Both these machines are provided with automatic control of two feed motions. The position location can be set by " dialling-in " the required dimension for each feed motion on six simple ten-position controls, the six controls being set up to a six-digit number corresponding to the dimension required in tens of inches, inches, and four decimal places. Alternatively, a punched-card system sets up all twelve controls simultaneously merely by pressing a button. The accuracy of location is better than 0·0002 in. on the Kearns machine and better than 0·0001 in. on the Newall.

Similarly, a very versatile automatic tracer control system will be shown in operation on a Giddings & Lewis 350-T horizontal milling and boring machine by the Rockwell Machine Tool Co. This equipment offers complete three-dimensional tracing, involving automatic control of any combination of three feed motions. It will be shown in operation cutting press tools, of complicated form for motor-car bodies.

The No. 18 " Rydermatic " (Fig. 41), exhibited by **Thomas Ryder & Son Ltd.**, of Bolton, is one of the company's standard vertical single-spindle semi-automatic multi-tool lathes. This machine, which is powered by a 25-hp motor and has been designed for heavy duty, will take work between centres or chuck work, and can be built either as two-slide models with one vertical turning slide and one horizontal facing slide, or as three-slide models with the addition of a universal slide. Air operation of the chuck and tailstock, together with single-lever control to the automatic cycle, enable fast production rates to be maintained with a minimum of operator fatigue. A worm-and-wheel final drive transmit power smoothly and efficiently, permitting the maximum tool life to be obtained from carbide tools.

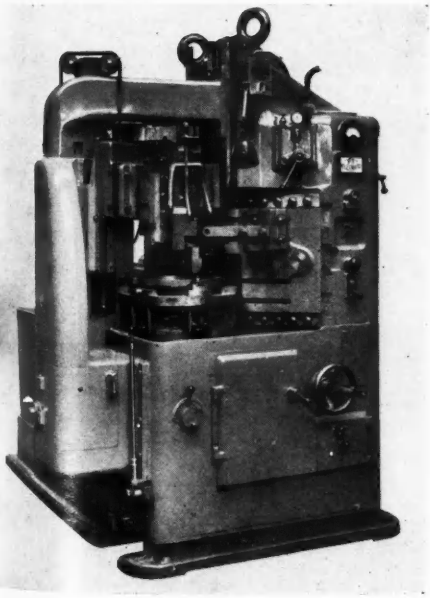

Fig. 41.

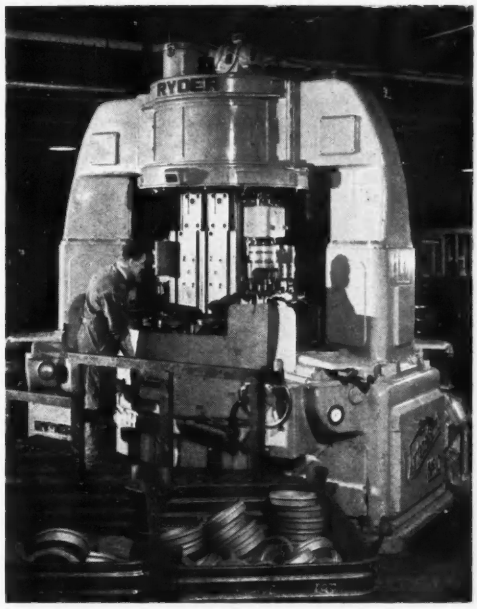

Fig. 42.

In addition to their No. 8T " Verticalauto ", Ryder are also exhibiting their No. 10/8 " Verticalauto " (Fig. 42), a heavy-duty, 8-spindle vertical chucking automatic, powered by a 60-hp motor and equipped with 14¼-in. diameter hydraulically operated chucks, eight turning slides, and four facing slides. A 6-spindle machine is also available, having the same power, but carrying 17-in. diameter chucks. Electro-hydraulic control of spindle clutches, indexing, lock-bolt, and spindle-carrier clamps operated by a single drum are features of this machine and provide a fully automatic cycle, with full hydraulic, mechanical, and electrical interlocking.

Demonstrations by **Radio Heaters Ltd.**, of Wokingham, Berks., will include the way in which induction heating raises productivity on brazing, local hardening, and soldering operations. These demonstrations will illustrate the precise, repetitive accuracy, freedom from scale, and cool working conditions which are inherent in the use of induction heating and which in themselves lead to higher production.

The new " Radyne " 25-kW induction-heating equipment will be exhibited for the first time. This equipment, like all other induction heaters in the 1- to 90-kW range of Radyne equipment, incorporates a smoothly variable heat-output transformer, giving a 20:1 control range and simultaneously and automatically ensuring correct matching with any work-coil used.

The 9-, 15-, and 25-kW induction heaters are all standardized in one compact frame size and, by designing to include a built-in water-cooling recirculator unit as an optional extra, the need for water mains or drains is eliminated. For the first time there is available a completely self-contained 25-kW equipment which, with its clear flat front, is ideal for mounting either a standard work-table, specially designed automatic handling fixtures, or flexible R.F. leads to feed melting furnaces or specialized vacuum plant.

Also to be exhibited will be the Radyne 3½-kW bench induction-heating equipment, stated to be the only bench unit in the world with a built-in variable R.F. heat-output transformer. In addition, the well-known Radyne 6-kW induction-heating equipment will be shown.

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A number of entirely new machines is being exhibited by **Humphris & Sons Ltd.**, of Poole, Dorset. Of these, the EP.10/F, series 2, 10-ton double-roll feed press is a direct development of the earlier CC.10/F and EP.10/F, series 1, machines. New features incorporated are in the main concerned with a new double roll feed with a rack-and-pinion drive. The feed is fitted with a built-in device to simplify strip feeding and is almost entirely enclosed. Furthermore, it is so constructed that feed direction can readily be reversed and can be adapted for use with almost any type of sidewheel, straight-sided, or endwheel press.

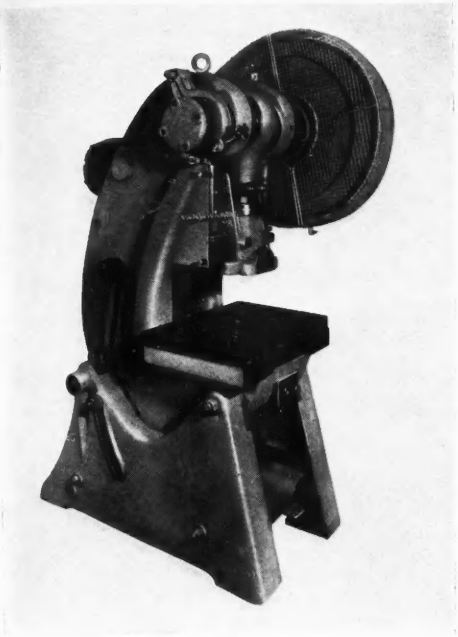


Fig. 43.

An interesting newcomer is the CP.25, 25-ton inclinable crank press (Fig. 43), which features a large bed area and a greater throat depth than that normally found on this size of machine. Switchgear is mounted on the side of the machine and is remotely operated by two readily accessible push-buttons fitted to the front of the press. The treadle bar and treadle cover can be located in any position between the stands of the machine, thus simplifying control, whichever direction is selected for feeding the material.

Other new machines being exhibited by Humphris include their 7.PS.10, 10-in. powered straightener ; their CD.800 Mark II combination decoiler and straightener ; their F.CP.25/F, 25-ton high-speed roll-feed press, which incorporates an electro-pneumatically controlled friction clutch and brake and a new rack-and-pinion double-roll feed with reversible feed direction ; their CP.LO-6 coil cradle ; and their S.C.I independent scrap cutter—a small, portable scrap-cutting unit intended for use with the smaller roll-feed presses which are not in themselves equipped with scrap cutters.

Exhibits by **Arthur Scrivener Ltd.**, of Birmingham, include their No. 1, No. 2, and No. 3 controlled-cycle, fully automatic centreless grinders. Of these, the No. 1 grinder has a grinding wheel 12 in. in diameter, a 5-hp main motor, a vibratory hopper, and a new swing-over transfer-finger loading device. The No. 2 grinder with a 20-in. diameter wheel and a 20-hp main motor, is fitted with the latest push-feed mechanism. The No. 3 grinder is an entirely new machine, fitted with a grinding wheel 20 in. in diameter by 10 in. in width, and a control-wheel diameter of 14 in. by 10 in. wide, giving a wheel opening of up to 9 in. This machine is powered by a 25-hp main motor, and is equipped with a new type of fully automatic overhead loader. All three models of these grinders exhibited are of the Scrivener controlled-cycle type, consisting of an automatic electro-mechanical system of closing the wheels of the grinder onto a work-piece which has to be plunge-ground, grinding the piece at a predetermined rate, opening the wheels again, and ejecting the ground piece. This system replaces the older method of opening and closing the wheels by means of a manually operated lever, and does away with the physical effort entailed by the older method. In addition, the Nos. 2 and 3 grinders exhibited are fitted with a new synchronous device which enables the final dwell, or sparking-out, of the piece on the grinding wheel to be readily adjusted from zero to 10 sec, thus greatly increasing the flexibility of the machine. Sparking-out time can be varied instantaneously within these limits by the simple adjustment of a pointer during the actual operation of the machine and without any change or adjustment of the original cam. A locking device prevents unauthorized interference with the setting.

Other Scrivener exhibits include their 6 × 18-in. and 8 × 24-in. reciprocating surface grinders, with grinding-wheel diameters of 7 and 10 in. respectively ; and their 30-in. duplex surface grinder, with two 30-in. grinding wheels, each powered by a 25-hp motor. This machine is being shown fitted with a roller-type through-feed unit for the simultaneous grinding of both faces of pump bodies.

Exhibits from **Saml. Denison & Son Ltd.**, of Leeds, include their new self-indicating universal testing machine, model T42C2. This machine (Fig. 44) has a maximum capacity of 20 tons, with four sub-capacities, making it extremely useful for testing a wide range of specimens. The load on the specimen is applied hydrau-

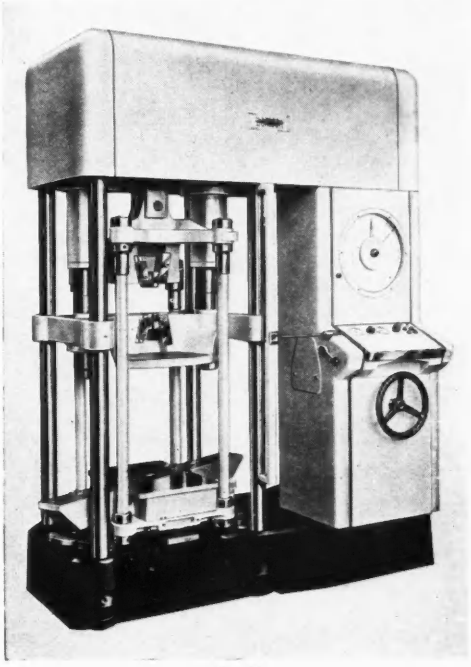
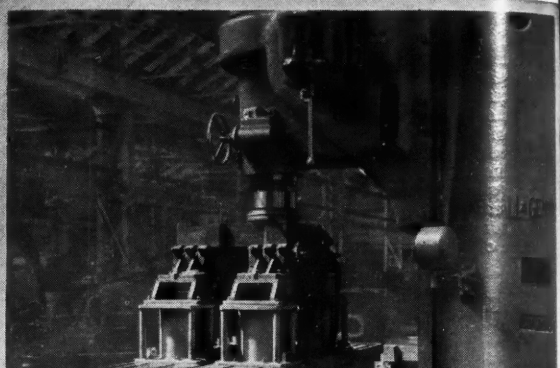
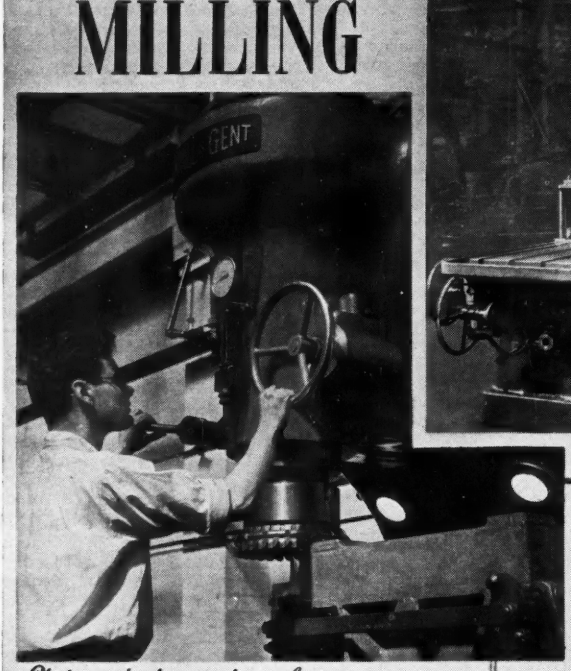


Fig. 44.

VERTICAL MILLING





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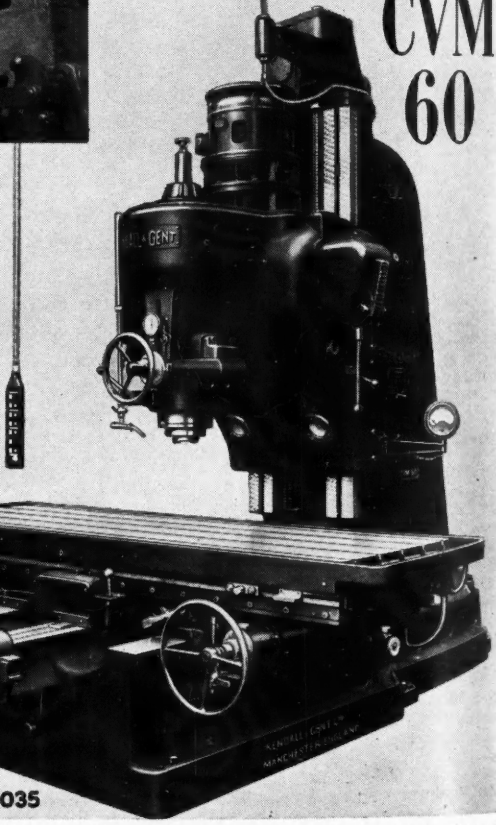

THE CVM.60 combines maximum production with extreme accuracy and easy operation. Powered by a 25 h.p. or 40 h.p. motor as required, spindle speeds range from 15 to 840 r.p.m. in eighteen steps. Rectangular table type has working surface of 9 ft x 2 ft 9 in, and traverses 7 ft 2 in x 3 ft 3 in, with a choice of four feed ranges. Other models available with circular table or combined circular and rectangular table. Maximum height under spindle nose is 3 ft 5 in.

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lically, but the measurement is made through highly sensitive knife-edge weighing levers.

This machine is available with various accessories for tests in tension, compression, transverse (three- and four-point loading), 180-deg. cold bend, double shear, Brinell hardness, punching, cupping, etc. Furthermore, it can be fitted with a load-pacing device, enabling the specimen to be loaded at a predetermined constant rate. If automatic graph recordings are required, it can be fitted with an autographic load/extension recorder in conjunction with a high-magnification mechanical extensometer.

A new high-precision measuring machine, capable of reading in three coordinates on standard scales to 0·00005 in. is being exhibited by the **Société Genevoise d'Instruments de Physique (SIP)**, of Geneva. The new machine (Fig. 45) removes all possibility of errors arising from the use of reference gauges by relating measurements to standard scales viewed through microscopes. Although originally constructed for the oil industry for the purpose of checking the large variety of conic thread couplings used for pipe-lines and boring equipment, this instrument has many other obvious applications in a wide range of fields, and is particularly suitable for the rapid and accurate measurement of all machined parts, thread-gauge rings and plugs (cylindrical and taper threads), and precision leadscrews.

Fig. 45.

The machine was originally intended to work in two coordinates, but by means of two accessories it is now possible to make measurements in three directions, i.e., longitudinal, transverse, and vertical. These accessories consist essentially of a transverse table mounted on the normal work-table and a short-focus microscope. This additional transverse table, with a built-in standard scale, has greatly extended the field of application of the machine, and permits measurements in two coordinates in the horizontal plane, as, for instance, in the inspection of turbine blades.

Other SIP exhibits include a range of high-precision jig-boring and milling machines, profile projectors, and optical measuring machines.

Exhibits from **Joshua Heap & Co. Limited**, of Ashton-under-Lyne, include their 2-in. automatic single-head tangential die-screwing machine (Fig. 46), arranged for driving from a constant-speed electric motor, and mounted on a cast-iron cabinet in which the motor is housed. This machine is fitted with the Heap patent

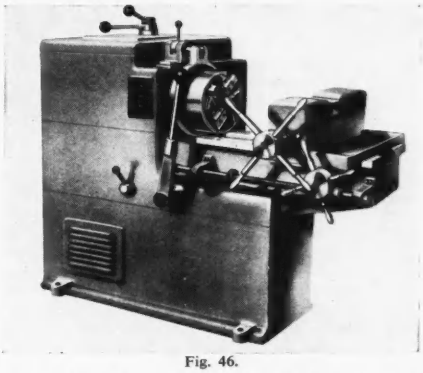

Fig. 46.

tangential diehead ; in addition to the hand releasing motion worked by a lever on the side of the machine, the dies open automatically when any predetermined length has been screwed, and close automatically on the return of the carriage. This machine, with a 2-in. capacity, is fitted with a roughing and finishing device, enabling threads over 1½ in. to be cut in two passes, although on sizes under 2 in. in diameter this is necessary only on tough alloy steels. The box-pattern vice is of the open-jaw self-centering type, and is extremely powerful and rigid. All the operating mechanism is totally enclosed, to prevent damage from swarf, and an automatic pump is supplied for the cutting lubricant.

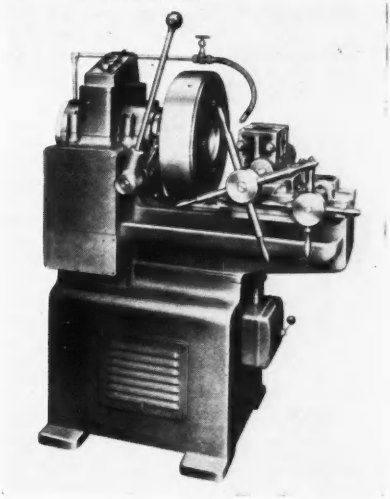

Fig. 47.

Another Heap exhibit is their 4-in. universal screwing machine (Fig. 47), which is a general-purpose unit fitted with a recently developed quick-release radial-type die-head. This machine can also be fitted with an ordinary cam-type radial diehead of either 3 or 4 in. capacity. A vessel and stand for the cutting lubricant are fitted to this machine, but these can be replaced by an automatic pump, if desired, the tank being incorporated in the base of the cabinet.

Other Heap exhibits include their 1-in., 2-in., and 6-in. automatic tangential diehead screwing machines, the rotary tangential diehead in the 6-in. machine having been newly developed. Until the introduction of this 6-in. diehead, the largest head of this type had a capacity of 4-in. bolts and pipes.

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Among a wide range of machine tools, **Burton, Griffiths & Co. Ltd.**, of Kitts Green, Birmingham, are exhibiting the new 6·5-kW, Mark III Sparcatron (Fig. 48). This new model embodies a number of important improvements, so much so that, in the spark-machining of hard metals and all types of dies, it is stated to be capable of operating from three to eight times as fast as the previous Mark II model, depending on the type of material and finish required.

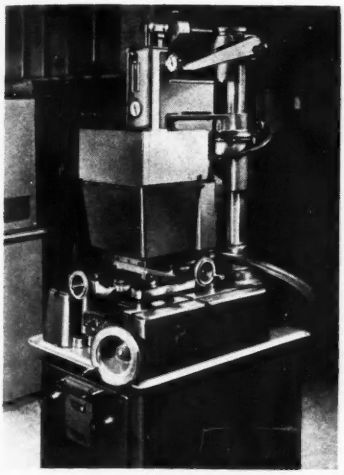


Fig. 48.

In the Mark III Sparcatron, maintenance of both the electrical and mechanical sections of the machine have been reduced to an absolute minimum, and all valves have been eliminated from the servo-control in the main control and auxiliary control cabinets. As a result of the new electrical circuit employed and the new servo-control, the machine is very stable in operation and requires no skilled adjustment. For ease of operation, the new servo-head is now raised and lowered by a conveniently located handwheel. However, the feature of previous models in which the servo-head can be swung aside to allow for the easy handling of heavy dies has been retained. Furthermore, the servo-head, in which the ram is positioned between two sets of balls operating in V-slides to ensure perfect accuracy, now incorporates a neat and accurate stroke-limit switch, which can be set quickly, so that the current is automatically cut off when the electrode has penetrated the workpiece to a predetermined depth. Throughout, the design is rigid and robust, the main column for the servo-head being 5 in. in diameter, and the sleeve of the bracket supporting the head being 10 in. in length, whilst the base on which the compound table is fitted is heavily webbed and is capable of carrying a weight of over 500 lb. The table tank has been increased in size to permit easier positioning of dies, and the settling tank in the base of the cabinet has been increased in capacity and incorporates a special arrangement of baffles to avoid debris from the machining operation being recirculated through the pump. If required, the table tank and compound table can be removed from the base casting, which has T-slots machined in its face, and a larger tank and compound table fitted. The efficiency of the machine is mainly due to the very sensitive servo-arrangement which controls the gap between the electrode and the workpiece, selected as required by the operator on the main control cabinet. On the new model, this has been still further improved by the use of a special motor in which the field winding has been eliminated, thus avoiding the generation of heat and the consequent possibility of the servo-head being affected by heat distortion. A very sensitive and quickly adjustable counterbalance is also fitted for the varying weights of electrodes. Fig. 49 is a close-up of the workpiece mounted on the table of the machine, with the electrode shown in position.

Fig. 49.

Other exhibits from Burton, Griffiths & Co. Ltd. include an Arter rotary surface grinder, model F.12 ; a Blanchard vertical-spindle surface grinder, model F.18 ; a Blohm horizontal-spindle surface grinder, type HFS.510 ; a Gisholt " Dynetric " balancing machine, type 1SV1 ; a Gisholt " Simplimetric " automatic lathe and a Gisholt vertical automatic production lathe, model No. 12V ; a Heyligenstaedt copy-turning lathe, type " Heycomat 2 " ; a Huller special-purpose machine with indexing table and a Huller vertical milling machine, No. FS4 ; a Maag gear-grinding machine, type HSS-60-BC, a Maag tooth-profile and helix-angle checking machine, type PH-100, and a Maag gear-cutting machine, type SH-75-C ; a Schiess horizontal milling and boring machine, model FB.28/16, a Schiess high-speed vertical boring mill, model KE125 ; a Deckel universal tool-milling and boring machine, type FP.2, a Deckel universal tool grinder, model S.1, and a Deckel universal pantograph die-sinking machine, model KF.12 ; a Boley turret lathe, type RD.25, and a Boley high-precision lathe, type DW.4 ; a Richmond 42-in. radial drilling machine, type HB.3/12 ; and B.S.A.-Huller tapping and threading machines.

Among other products exhibited by **Manchester Oil Refinery (Sales) Ltd.**, of Trafford Park, Manchester, is a number of new cutting oils which have been specially developed for the machining of the tougher metals, including nimonic and titanium alloy steels. These products are " Ferromor A and B ", which are sulphurized cutting oils containing sulphur in active form, and which are especially suitable for machining steels in the medium and higher tensile classes ; " Halmor 9 ", a low-viscosity, active, sulpho-chlorinated oil for the machining of high-tensile steels and work-hardening materials ; and " Halmor 10 ", a relatively high-viscosity oil with a very high concentration of extreme-pressure agents of the sulpho-chlorinated variety, particularly suitable for very arduous operations of the slower type on extremely tough materials.

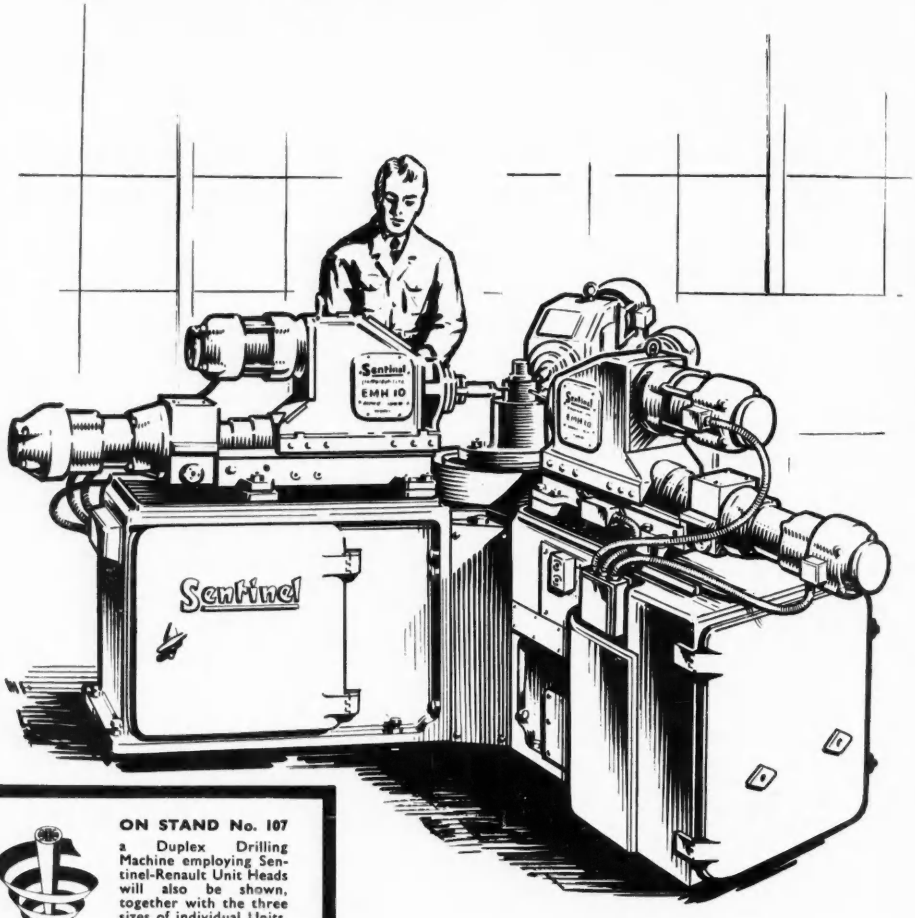
Other exhibits by the Company include a group of new non-destructive dye penetrant inks. These additions to the M.O.R. range of flaw-detection materials give rapid and positive indications of surface flaws in metal components, and are supplied in pressurized cans, enabling the inks to be applied easily and quickly as a fine spray.

In addition to a comprehensive range of machine tools and production equipment, including universal boring and facing heads with self-acting power feed, " Perfect Grip " expanding arbors, mandrels, and chucks, and MSE Fette self-opening thread-rolling heads, **Machine Shop Equipment Ltd.**, of London, S.W.1, are exhibiting the new Wohlhaupter universal taper boring

Sentinel

THREE-WAY HORIZONTAL DRILLING MACHINE

This machine is designed for the simultaneous drilling of three radially positioned holes. A fabricated steel base carries a central fixture, which holds the component for machining. The three Sentinel-Renault unit heads are mounted on standard cast iron bed extensions. The machining cycle is automatic, and is push button controlled from the front of the machine.



ON STAND No. 107

a Duplex Drilling Machine employing Sentinel-Renault Unit Heads will also be shown, together with the three sizes of individual Units, EMH. 10, EMH.20, EMH. 30.

SENTINEL (SHREWSBURY) LIMITED SHREWSBURY

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A METAL INDUSTRIES GROUP COMPANY

SS/31/3546

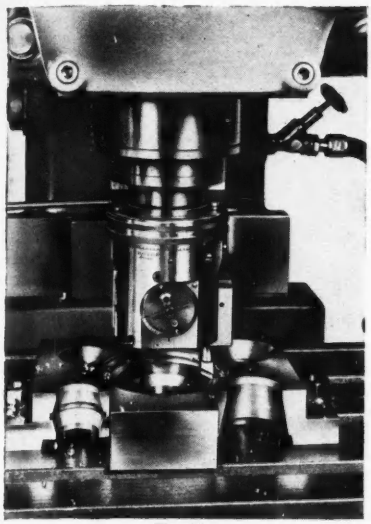


Fig. 50.

and turning head, type UK4. In this new tool (Fig. 50), which has never before been shown in Great Britain, the angular setting is entirely incorporated in the head. Any internal or external taper up to 180 deg., with a maximum taper surface length of 1·400 in. can be produced. The head can be mounted on boring, jig-boring, milling, and drilling machines, and on lathes and special-purpose machines, eliminating the need for time-consuming reclamping and locating of the workpiece. The boring bit operates with a constant feed of 0·0022 in. per revolution of the head at any taper angle. The slide is returned to the starting position at the end of the cut by engaging the rapid return while the head still rotates, the rapid-return rate being ten times the working feed. The diameter of the taper is set by means of a cross-setting spindle and a scale. Special control cams can be built in for form-turning or boring.

Fig. 51.

Another new tool exhibited by Machine Shop Equipment Ltd. for the first time is the Swiss-made " Endex " milling cutter (Fig. 51). This tool is designed to point round or polygonal bar ends, and to round, point, flatten, and chamfer bare ends and mass-produced parts in straight or bent finish. The tool comprises a split tool-carrier, a gang of milling cutters made of super-speed steel, and interchangeable stock-centering discs for various diameters of material. The cutters can be ground to any desired shape, so that they cut right to the centre. The Endex can be used as a revolving tool on any suitable machine tool and, if required, it can also be mounted rigidly on a turret lathe or centering machine, the centering discs ensuring perfect guiding of the workpiece. When the cutters need regrinding, the tool can be dismantled very easily, and their patented design enables the cutters to be resharpened many times.

Other entirely new exhibits from Machine Shop Equipment Ltd. include the MSE coolant centrifuge for clarifying grinding and honing coolant—a fully enclosed and exceptionally compact unit, operating with a remarkably high degree of efficiency ; and the MSE Fette thread-rolling machine, manufactured by Fette, of Schwarzenbek, Hamburg, which has been specially designed to accommodate a range of MSE Fette self-opening thread-rolling heads, and which is ideally suited for batch or large-scale production of threaded components.

Among the comprehensive range of specially designed portable spot-welding equipment exhibited by the **ARO Machinery Company Ltd.**, of London, S.W.13, a particularly interesting unit is their model P.192, which is a 100% water-cooled gun. In this welder (Fig. 52), not only are the transformer and electrode tips water-cooled, but also the electrode carriers themselves and the braided link connecting the transformer to the electrode carriers. As a result, all "hot points" are eliminated from the gun, even on continuous work on very heavy gauges. The gun, which weighs only 25 lb, has a capacity of 14 s.w.g. + 14 s.w.g. or 16 s.w.g. + $\frac{1}{4}$ in. (sheets), or $\frac{1}{4}$ in. + $\frac{1}{4}$ in. (rounds), the production rate being 4000 spots per hour on 20 s.w.g. + 20 s.w.g.

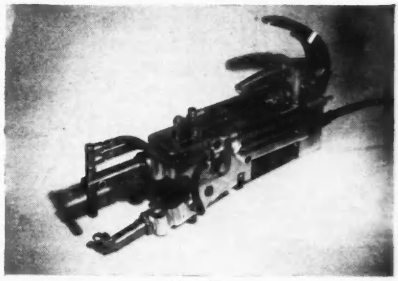
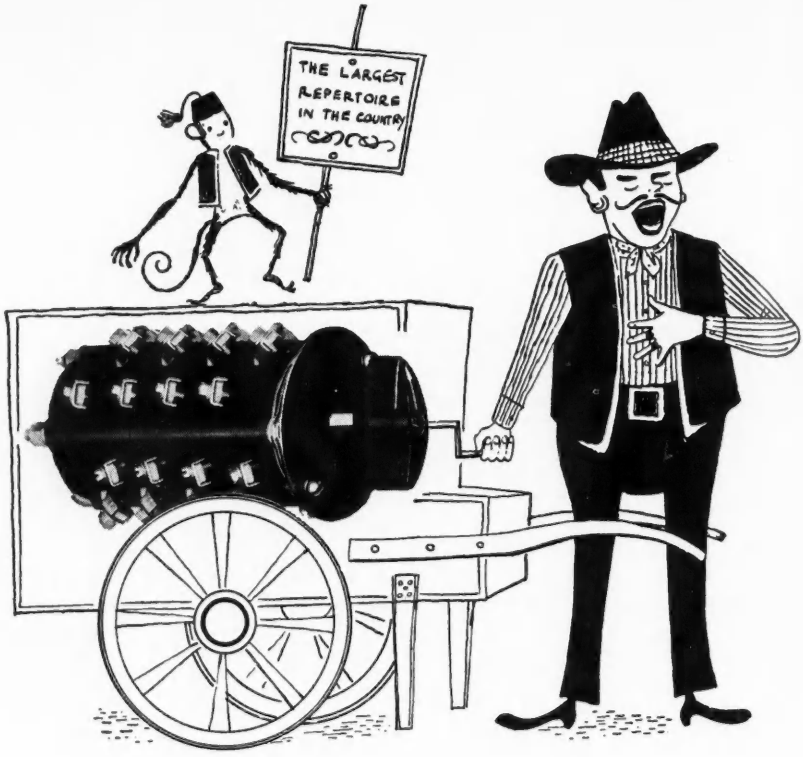


Fig. 52.

Other equipment exhibited by ARO includes their P.159 gun, which is an ultra-lightweight unit of only 15 lb ; their P 166 gun, weighing 23 lb, and incorporating a built-in trip-switch ; their P.281, an air-cooled unit for short production runs on gauges up to $\frac{1}{8}$ in. + $\frac{1}{8}$ in. ; their P.293 unit, intended for high production rates on gauges up to $\frac{1}{8}$ in. + $\frac{1}{8}$ in. (sheets), or $\frac{3}{8}$ in. + $\frac{3}{8}$ in. (rounds), and fitted with a water-cooled transformer and electrodes ; their D P45, which is a twin-spot gun specially designed to be incorporated as an independent welding head in multi-head, multi-spot machines ; and their P.413A, one of their latest models, air/hydraulically operated and combining great manoeuvrability with low capital outlay and easy maintenance. A complete range of automatic timer units is available for use with all these guns. These units work on the condenser-charging system, and a special safety device ensures that the welding current is cut off in the event of the earth link being broken.

Among a wide range of precision lathe chucks exhibited by **F. Burnerd & Co. Ltd.**, of London, S.E.3, their new 3-jaw and 6-jaw " Griptru " chucks, exhibited for the first time, are of special interest. These chucks are fitted with a micro-concentricity feature, enabling accuracy of concentricity to be adjusted to within 0·0002 in. total indicator reading—a degree of accuracy claimed to be unobtainable from any other type of lathe chuck. At the same time, these chucks retain all the flexibility of orthodox self-centering chucks ; further-



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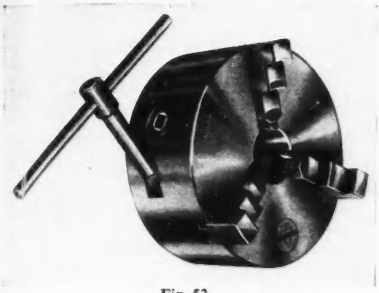


Fig. 53.

more, the bore dimension is not restricted in any way, thereby permitting a much wider range of work to be handled than is possible with any one type or size of collet. In operation, when a component has been gripped, the micro-adjustment screws are slackened off with the dual-purpose key provided. A dial-gauge is then mounted in position and the chuck is rotated until the lowest reading is obtained. The micro-adjustment screw nearest to the low reading is then tightened until the gauge needle moves to half of the total eccentricity value originally recorded. The chuck is then rotated again and the gauge reading checked, this operation being repeated, if necessary, until the desired degree of accuracy has been obtained. Once set for a given diameter, no further adjustment is required for components of the same diameter. A 3-jaw "Griptru" backplate-pattern chuck is illustrated in Fig. 53.

Other Burnerd exhibits include their 3- and 4-jaw geared scroll self-centering chucks, their 4-jaw independent reversible-jaw chucks, and a selection of instrument-makers' lathe chucks, lever scroll chucks, and direct-mounting chucks.

Torque Irregularities in Flexible Couplings

(*Concluded from page 235*).

the total fluctuating torque being $T = T_1 + T_2$, where T_0 = mean transmitted torque. For rigid couplings $C_{T_1} < C_T$, where $C_T = T/T_0$, whereas for flexible couplings $C_{T_2} < C_T$.

To determine the optimum stiffness of a flexible coupling the following procedure is indicated :—

(a) From the maximum permissible torque irregularity C_{T_2} of the second rotor, determine T_2 as $T_2 = C_{T_2}T_0$.

(b) Determine the corresponding torque transmission ratio R required to obtain this T_2-value from a known (or assumed) value for $T_{2\,\text{rigid}}$, using the previous relations.

(c) Determine ω_n from $R = 1/[1 - (n\omega/\omega_n)^2]$ for sinusoidal torques of phase velocity $n\omega$, or from $R_p = 1 - \cos\ \omega_n t$ for load changes or impact torques. (In the case of R_p, estimate also the duration t of the load change or impact, since it is necessary that $t < \pi/\omega_n$. For couplings used with internal combustion engines, ω_n should be below the uniform phase velocity of the lowest running speed N of the engine, i.e., $\omega_n < 2\pi N/60$.)

(d) Evaluate the stiffness of the coupling as $k = \omega_n^2/[(1/J_1) + (1/J_2)]$.

The calculated results are not always applicable in practice. In some applications the couplings at present available are not sufficiently flexible ; in others the irregularity of the first rotor, which should always be considered as well, becomes excessive. In the latter case, an increased flywheel mass will usually produce an improvement ; in the former case, it is still necessary to produce even more highly flexible couplings.

The above considerations can be applied with hardly any modifications to belts, fluid or electromagnetic couplings, and other flexible elements.

Limits of Application of Flywheels and Flexible Couplings

A cyclically varying torque generated at a mass J_1 can be reduced only by means of a flywheel. The effect of this torque on J_1 can be decreased by a rigid coupling to the driven mass J_2, provided that the effect on J_2 is acceptable. These statements also apply to load-change torques.

For shock loads originating at J_1, the extra flywheel mass at J_1 and the rigid coupling produce unfavourable results, because the peak value of the impact is increased when J_1 is made larger. To cope with shock loads, a very flexible coupling with a natural frequency such that $\omega_n < \pi/t$, where t = duration of impact, is necessary.

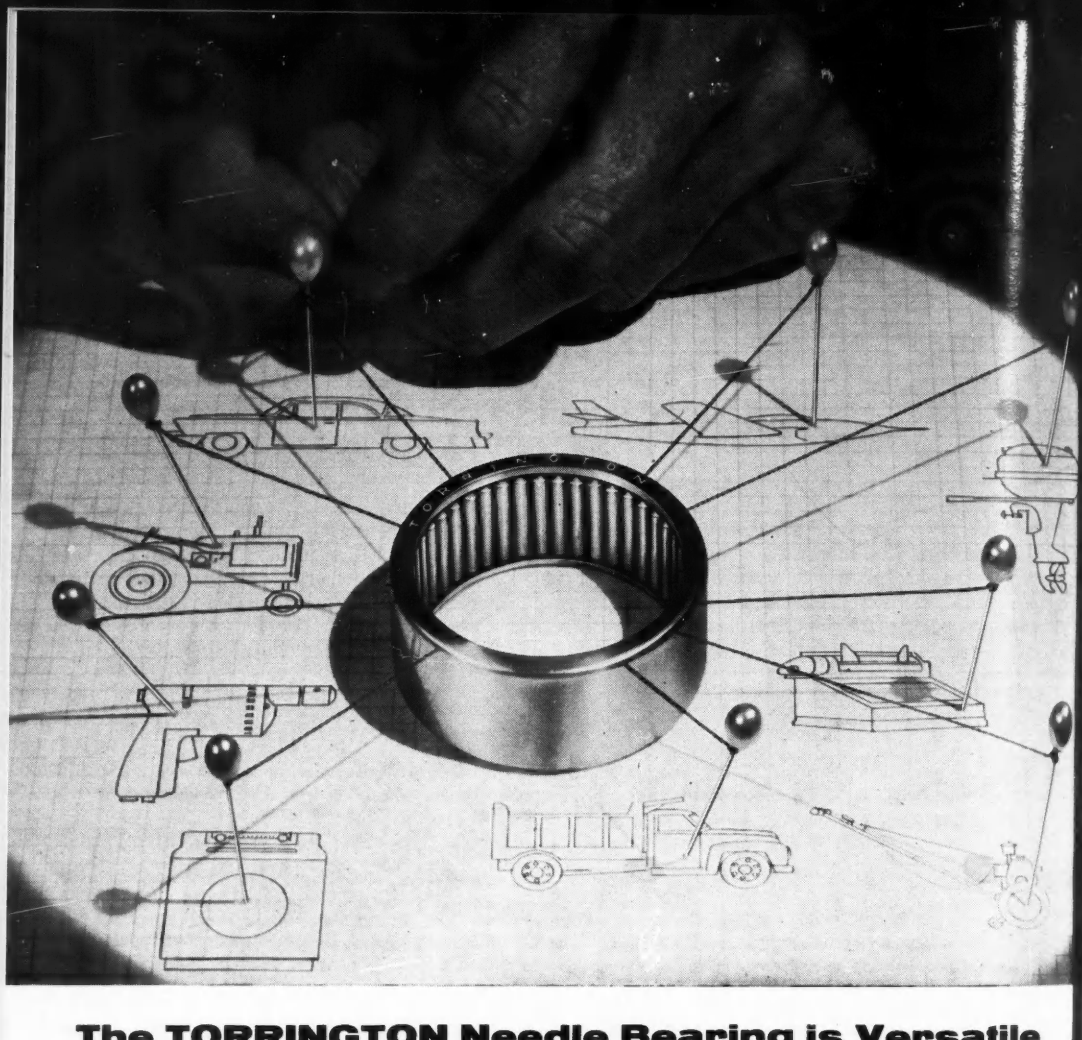
The transient conditions during starting must be carefully considered. The use of a large flywheel increases the length of the starting period. For asynchronous motors, the starting torque may be 3 to 8 times greater than the normal torque, and this makes it difficult to employ a very flexible coupling. A solution is to combine the coupling (e.g., a "tyre-type" coupling) with a friction-plate clutch. Owing to the slip occurring during starting, the asynchronous motor can be run up to speed very rapidly, while the driven machine is accelerated over a longer period.

The large flywheel also increases the time required to pass through "critical-speed" ranges of engines. With a friction-plate and the flexible coupling, the transient can be passed without building up large torsional vibrations, particularly if there is also some damping action in the coupling.

Applications occur where it is desired to produce high torque fluctuations through impact action (crushers, hammers, etc.). In such cases J_1 should, of course, have a large flywheel. However, if irregularity of motion only is desired at J_1, this mass should not have much flywheel effect, and should be loosely coupled to any further mass in the system.

Thus, both flywheels and flexible couplings can be used to lessen or to increase the irregularities of individual machines, and suitable values for both components can be determined by calculation. Where the cyclic irregularity is so large that it cannot be dealt with by a flexible coupling, it will first have to be reduced to an acceptable value by means of a flywheel. Even more flexible couplings will be needed for such cases.

Finally, it is possible that two machines both produce fluctuating torques. This case occurs, for instance, with a diesel engine coupled to an alternator connected to an asynchronous motor. The flexible coupling by itself then is not sufficient. There are two possible solutions, i.e., a large common flywheel and a rigid coupling, or two smaller separate flywheels (one for each machine) and a flexible coupling. The decision as to which is more suitable may also depend on various other operating requirements.



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NEWS OF THE MONTH

PERSONAL

Mr. R. Appleby, director and general manager of Black & Decker Ltd., Harmondsworth, Middlesex, has been appointed director of international operations to the parent company, Black & Decker Manufacturing Co., Towson, U.S.A.

Mr. A. Boyes has been elected to the Board of East Sussex Engineering Co. Ltd., Lewes, Sussex, and will act as director and general manager of the company.

Mr. Geoffrey Eley has been elected chairman of the Board of The Brush Group Ltd. **Mr. Miles Beevor** has been elected deputy chairman and has been appointed joint managing director. **Mr. Ian T. Morrow** has been appointed joint managing director.

Colonel J. A. Fitzpatrick has been appointed by the Minister of Supply, with the agreement of the Secretary of State for War, to be Director of Fighting Vehicles, in succession to Brigadier C. W. M. Timmis, D.S.O., O.B.E. He has been granted the acting rank of Brigadier on taking up his new duties.

Mr. D. K. Fraser has been appointed managing director of Petters Ltd., Staines, Middlesex.

Mr. A. H. Goude has been appointed head office sales manager of A.E.I. Lamp and Lighting Co. Ltd., Crown House, Aldwych, London W.C.2. **Mr. R. P. B. Voaden, A.M.I.E.E.**, has been appointed regional manager, Midland Region, and **Mr. G. W. Nattrass** has been appointed regional manager, North East Region.

Air Vice-Marshal Sir William Havers, K.B.E., C.B., has joined the Board of Bristol Repetition Ltd., Feeder Road, Bristol 2.

Mr. Frank Holmes has been appointed chief purchasing officer of Hadfields Ltd., East Hecla Works, Sheffield 9.

Mr. Ralph Hussey has been appointed sales manager of the Boiler Division of Elliott Brothers (London) Ltd., Century Works, London S.E.13, and will handle instrumentation for steam power plants and heating and ventilating services.

Mr. C. F. Lawson has been appointed foundry manager of the Distington Engineering Co. Ltd., Workington, Cumberland. **Mr. G. Ellis** will act as personal assistant to the general works manager, and **Mr. C. Scott** has relinquished his post as assistant works manager.

Mr. R. F. Marshall, B.Sc.(Eng.), A.M.I.Mech.E., has been appointed manager of the Education Department of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17, in succession to the late **Mr. Kenneth R. Evans.**

Mr. John Meager, M.I.Ex., has been promoted to the position of works office manager at the Plymouth Works of Acheson Colloids Ltd. **Mr. D. E. H. Hamilton** and **Mr. E. Matthews** have joined the sales staff of the company.

Mr. F. S. Mitman, deputy chairman and managing director of Borg-Warner Ltd., Letchworth, Herts., has been elected chairman of Hartcliffe, Lee and Malkin Ltd., Salford, Lancashire, the shares of which have been acquired by Borg-Warner Ltd. **Mr. W. Harney** will continue as managing director.

Mr. Ian T. Morrow, C.A., F.C.W.A., joint managing director of The Brush Group Ltd., has been elected President of the Institute of Cost and Works Accountants. **Mr. H. J. Furness**, chief cost accountant of Hoover Ltd., has been re-elected vice president, and **Mr. J. Borsay**, chief accountant of Ferguson Pailin Ltd., has been elected vice president.

Mr. David J. Munroe has been elected President of the Webster Electric Company, Racine, Wisconsin, U.S.A., to succeed **Mr. Preston G. Crewe**, who has been elevated to the newly created post of vice-chairman of the Board. **Mr. Arthur C. Kleckner** has been re-elected chairman of the Board.

Mr. H. P. Potts, M.I.Mech.E., M.I.Prod.E., has been appointed managing director of the B.S.A. Small Heath Group on the retirement of **Mr. James Leek, C.B.E.**, on the 31st of July, 1956. Mr. Potts will continue in his present position as managing director of the B.S.A. Tools Group. **Mr. S. A. Roberts**, at present general manager and director of the Tools Group, has been appointed deputy managing director with effect from the 1st of August, 1956. Arising from this re-organization from the 1st of August, 1956, **Mr. T. N. Woof**, at present sales director of Burton, Griffiths will become general manager and **Mr. F. A. Janes** will be appointed sales director.

Mr. John Spencer Rivaz, A.R.Ae.S., has been appointed technical sales manager to Smiths Aircraft Instruments Ltd., Cricklewood, London N.W.2. **Mr. Douglas G. Johnson**, personal assistant to **Mr. Leonard Morgan**, director and general manager, has been appointed contracts manager.

Mr. H. V. Schofield, M.I.E.E., sales director of Chloride Electrical Storage Co. Ltd., has retired from active duties, but will remain a member of the Board. **Mr. Edward Powell**, director and sales manager of Chloride Batteries Ltd., has been appointed general sales manager of the whole Chloride Electrical Group. **Mr. A. C. Stewart** has been appointed to assume full responsibility as sales manager of Chloride Batteries Ltd.

Mr. Austin Skromme, design engineer of Caterpillar Tractor Co., Peoria, Illinois, has been appointed to the engineering staff of Caterpillar Tractor Co. Ltd., Desford, Leicester. **Mr. John Deffenbaugh** is chief engineer of the company.

Mr. Clifford Smith, A.M.I.E.E., has been appointed manager of the Marine Department of The General Electric Co. Ltd., Magnet House, Kingsway, London W.C.2.

Mr. G. Darsley Smith has been re-elected chairman of the Radio Industry Council. **Mr. G. A. Marriott** has been re-elected vice-chairman.

Mr. W. H. Stephens, Head of the Guided Weapons Department of the Royal Aircraft Establishment, has been appointed by the Ministry of Supply Deputy Director (Equipment) of the Royal Aircraft Establishment, in succession to **Dr. F. E. Jones**, who is retiring from Government service.

Mr. S. F. Steward, C.B.E., managing director of Lancashire Dynamo Holdings Ltd., St. Stephen's House, Victoria Embankment, London S.W.1, has been elected chairman of Lancashire Dynamo Electronic Products Ltd., whose works is at Rugeley, Staffordshire.

Mr. J. Strachan, A.M.I.E.E., has been appointed technical sales engineer for Scotland for Erskine, Heap & Co. Ltd., Manchester.

Mr. Edward Ward has joined Diesel Equipment Ltd., Uxbridge, Middlesex, as general manager of the company.

Mr. H. de G. Warter has been appointed public relations officer of the Regent Oil Co. Ltd., 117 Park Street, London W.1.

AUTOMATION NO THREAT

The popular misconception that automation was a threat to industry has been described as being " unrealistic to the point of being fantastic ", by Mr. John Pascoe, chairman and managing director of British Timken Limited.

Speaking at the annual meeting of the company in Birmingham, Mr. Pascoe said that great attention had been given to automation by the importation of the word from the United States. The convenience of being able to describe the present phase of technical development in manufacturing methods by one, although ugly, word " automation " had led to a spate of writing, very little of which had any relation to fact.

Now the prevalent idea was that we were on the eve of displacement of large numbers of workers by automatic brains and robot-manned factories. That was unrealistic to the point of being fantastic.

As had always happened throughout industry, the development of new manufacturing techniques would naturally mean the transfer of some workers from one industry to another.

" To me," said Mr. Pascoe, " the problem would seem to be whether the older industries will be able to lessen their demands for workers rapidly enough to permit the new industries, which grow up year by year, to satisfy their demands for manpower."

It had been said by a prominent industrialist in the United States of America that half of to-day's labour force in that country was engaged in the production and distribution of products not even heard of fifty years ago, and that, with the acceleration of modern development, the next twenty-five years was likely to show a similar shift in the working population.

The undoubted pattern of the past and forecast of the future must, on a little consideration, mean that all that was covered by the word " automation " could not be regarded as a tragedy to our working population, but rather a definite promise of increasing standards of living in the future.

EFFICIENCY EXPERTS DISCUSS AUTOMATION

Automation and its impact on industry played a large part in the discussions of the Institute of Cost and Works Accountants at its National Cost Conference at Edinburgh on June 1. The Institute is the professional and examining body of accountants specializing in industrial and commercial efficiency.

In his presidential address, Mr. George Nicholson, F.C.W.A., warned industry not to assume that a new industrial revolution through automation is the answer to the problems of productivity and exports. " This," he said, " is complacency at its worst.

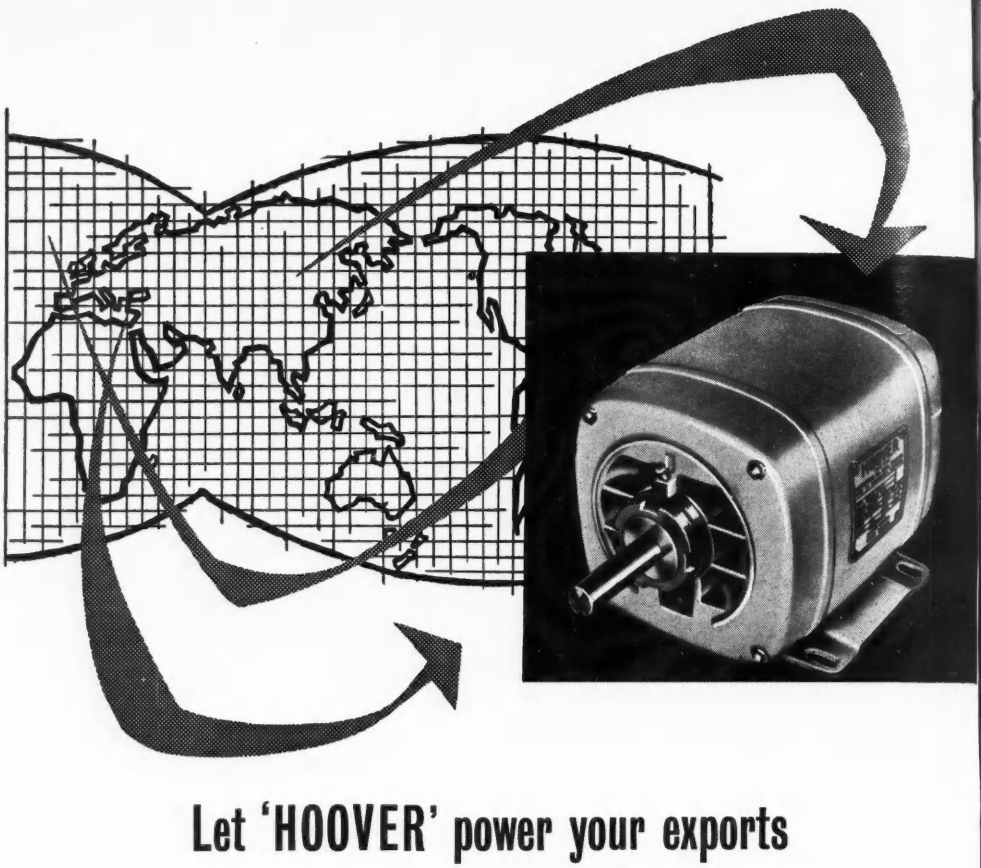
" Unfortunately, there has been a lot of widespread comment, some creating widespread consternation and others seeming to promise an even lazier life for industry with talk, not of more production, but of shorter working days and a shorter working week. If this latter view prevails it can hardly be, in the short run, a cure for our present problems.

" Intelligently used, the latest development in automatic machinery will increase the productive resources of this country, but the increases will not come without a lot of thought, careful planning and the utmost co-operation among everyone in industry."

The two papers presented to the conference also dealt with automation from different aspects. The papers were : " The Impact of Automation on Management Accounting " by Mr. David J. Young, C.A., F.C.W.A., secretary and comptroller, The Steel Company of Wales Ltd., and " Looking Forward " by Mr. Reginald W. Duffield, F.C.W.A., of the Molins Machine Company Ltd.

Mr. Young said that with high taxation and inflation, it had become theoretically impossible to finance the large-scale capital developments which automation required without the aid of new and continuing finance. If industry were not allowed to set aside adequate funds itself, then they must be available when required out of the savings and pension schemes of the people.

Mr. Duffield considered the effect of automation on labour relations. " In the past, as new skills have been developed and old ones have died out, labour re-deployment has ' happened ', but the process, in the short run, has caused individual hardship, and it is the short run prospect which counts for the individual. In the long run, increase in productivity creates new jobs and unemployment is held at bay."



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" URANIUM AND ATOMIC INDUSTRY "

The " Uranium and Atomic Industry " conference will be held at the Cosmopolitan Hotel in Denver on June 25 and 26. Walker L. Cisler, President of the Atomic Industrial Forum of New York City and Shirley A. Johnson, Jr., director of the Denver Research Institute of the University of Denver are co-sponsors of the meeting.

Discussions on Uranium Production will officially open sessions at 9.30 a.m. Donald Everhart, geologic adviser to the AEC will speak on Uranium Geology ; Philip Merrit, senior geologist of the E. J. Longyear Company will speak on Exploration and Development of Uranium. John B. Knaebel, manager of the New Mexico Uranium Operations of the Anaconda Copper Mining Company will speak on Significant Developments in the Mining of Uranium. Dr. Alex Stewart, director of research for the National Lead Company will talk on the Processing of Uranium.

Monday afternoon's discussions will centre around the Demands for Atomic Energy. C. D. W. Thornton, assistant to the President of Farnsworth Electronics Company will speak on Nuclear Power. John J. McMullen, Chief of the Office of Ship Construction, U.S. Maritime Commission, will speak on Propulsion. Ewell E. Mason of the International Nuclear Corporation will talk on Radiation and the speaker for Process and Space Heat as a Demand for Atomic Energy will be announced at a later date.

Banquet speaker on Monday night will be Jesse C. Johnson, director of the AEC Raw Material Division, whose topic will be "AEC's Programme and Policies in the Uranium Field ".

Tuesday morning, June 26, will find conferees discussing competitive energy sources. Dr. Amasa Bishop, Chief of the AEC Controlled Thermonuclear Branch, will discuss " Fusion ". Mr. W. Brice O'Brien, assistant counsel for the National Coal Association, will speak on Energy from Coal. Mr. Wallace Pratt, consulting geologist from Carlsbad, New Mexico, will speak on Energy from Petroleum. The speaker for Solar Energy as a Competitive Energy Source will be announced at a later date.

Tuesday afternoon's subject of Related Aspects will find R. E. Barrett, manager of Uranium Procurement for Atomic Energy of Canada Ltd., speaking on Uranium Development in Canada. Howard E. Kremers, technical assistant to the President of Lindsay Chemicals Company, will speak on the Demand for Thorium. Philip Mullenbach, director of Atomic Energy Project, National Planning Association, will speak on International Requirements of Atomic Energy, and will be followed by a discussion of U.S. Laws and Regulations.

Some 250 of the expected attendance of 400 leaders of the atomic and mining industries, the financial world, government and education will leave Tuesday evening by special railroad cars for a two-day tour of the Colorado Plateau. The tour will feature visits to the MiVida and Rattlesnake Pit mines near Moab, Utah, a tour of the Uranium Reduction Company mill at Moab, tours of National Lead Company and Climax Uranium Company mills at Grand Junction, Colorado, and barbecues at Dead Horse Point, Utah, and Colorado National Monument.

Full information on registration, programme, field trip, hotel accommodation, etc., are available by writing to the Conference Committee, Denver Research Institute, University of Denver, Denver 10, Colorado.

EUROPEAN MACHINE TOOL EXHIBITION, 1957

The 5th European Machine Tool Exhibition will be held in Hanover, Germany, from September 15 to 24, 1957. Rules governing this exhibition will be substantially the same as those for the fourth of the series which was staged in Milan. It has been decided, however, that stand rental (of D.M. 100 per sq. metre) will also cover the use of cranes for erecting and dismantling machines, and rail transport charged from Hanover-Wulfel to the exhibition grounds.

Exhibitors are reminded that if they wish to show their products at Hanover, they may not participate, in 1957, in " any other fair or exhibition staged in a country in membership of the European Committee ". This restriction applies also to the showing of machines by agents, and to the loan of machines for demonstration purposes. The regulation of the European Committee cannot be overridden by any permission relaxing the M.T.T.A. Bond, such as that normally given in respect of the display of presses and other sheet metal working equipment at the B.I.F. and the Engineering Marine and Welding Exhibition.

" THE WORLD'S GREATEST AIR SHOW "

A jet-age review of aircraft, products of the revolution which in a single decade has smashed the sound barrier and created new conceptions of war and peace, will be on view in early September when the Society stages its 17th Flying Display and Exhibition. Individual displays by Great Britain's most successful—and most recent—aircraft will be watched by many thousands of guests from home and overseas who, in the words of the Society's President, J. J. Parkes, " have come to regard a visit to the Display as an essential part of their year's activities ". Only last year, the vast Exhibition Hall had to be increased in size to accommodate the products of a record number of manufacturers. This year, the Hall is to be made even larger, as no fewer than 338 companies—some twenty more than in 1955—will be displaying their wares which will range from complete aircraft to washers, and aero-engines to nuts and bolts.

The Physical Society Exhibition in 1957 will be held in both the Old and New Halls of the Royal Horticultural Society, Westminster, London S.W.1. The dates of the Exhibition are the 25th to 28th March, inclusive.

BUSINESS NOTES

Henry Wiggin & Co. Ltd., Thames House, Millbank, London S.W.1, have purchased the specialized high nickel alloy fabricating plant at Hereford, which they designed and erected for the Ministry of Supply and have been operating since 1954.

Liquid Systems Ltd., Union Road, Croydon, Surrey, announce that they are now manufacturing and marketing in Great Britain the Bowser Oil Lubricating and Filtration Systems.

Pegson Ltd., Coalville, Leics., announce that their telephone number has been changed to Coalville 1234 (10 lines).

The Compoflex Co. Ltd. announce that they are moving on 2nd July to larger premises at 23-25 Northumberland Avenue, London W.C.2. Tel. No.: TRAfalgar 7800. The Southern Flexible Centre of Compoflex Ltd. will also move to the same premises, whilst the Design and Development Establishment will remain at Godalming, Surrey.

Midland Silicones Ltd., 19 Upper Brook Street, London W.1, announce that their Birmingham branch office has moved to larger and more central premises at Union Chambers, 63 Temple Row, Birmingham 2. Tel. No.: Midland 7705.

Simms Motor Units Ltd., East Finchley, London N.2, announce that they have acquired from the Southern Areas Electric Corporation Ltd. the whole share capital of Mono-Cam Ltd., Molesey. **Mr. G. E. Liardet**, chairman and managing director of Simms Motor Units Ltd., has been elected chairman, and Mr. John Ayres and Mr. C. H. Bradbury, directors of Mono-Cam Ltd. Mr. W. Friedlander has been appointed director of research and will be working in close liaison with Mr. Bradbury, chief technical executive of the Simms Group.

The Newall Engineering Co. Ltd. of Peterborough, announce that an agreement has been signed by themselves and The Fosdick Machine Tool Co. Ltd., of Cincinnati, U.S.A., whereby the latter company will employ, under licence and U.S. patent No. 2,580,255, the Newall system for automatic table positioning in their Jig Boring machines. This arrangement follows a similar agreement concluded with Berliner Maschinenbau-Aktien-Gesellschaft, authorizing the West German organization to incorporate the same system in their Bemag Jig Boring and Milling machine, type KBF2.

The adoption of the Newall patented system by two companies of such international standing as Fosdick and Berliner Maschinenbau-Aktien-Gesellschaft undoubtedly enhances the considerable prestige of The Newall Engineering Co. Ltd. in the field of precision machine tool development.

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It is of interest to record that Newall have a number of design patents for the establishment of highly accurate measuring systems to their credit, and that the organization is now extending its influence in this direction by the production of two new Jig Borers employing alternative methods of table location. In the " Spacematic " machine, the measuring system, developed in conjunction with The British Thomson-Houston Company Ltd., consists of bars in which are incorporated reference units accurately spaced at one inch intervals and an electro-magnetic detecting head is positioned by means of a remotely controlled micrometer to the required decimal proportion of one inch. The head is capable of detecting errors in position to an accuracy of twenty millionths of an inch. The system provides automatic positioning by dial setting, or through insertion of cards punched with co-ordinate dimensions for longitudinal and transverse movement of the table.

As an alternative to the established Newall system of table location by use of rollers and micro-locators, the 2436 Mark II Production Jig Borer is to be equipped with an optical system of patented design and manufactured by Optical Measuring Tools Ltd., one of the Newall Group of Companies. This provides facilities for pre-setting, and an additional feature is that zeroing can be accomplished at any position in the range of travel of both table and cross-slide.

The " Spacematic ", " Optical 2436 " and " 2436 Mark II " production Jig Borers will all be demonstrated at the forthcoming International Machine Tool Exhibition.

New Permali factory in the U.S.A. Mr. A. A. Heath, managing director of Permali Limited, was recently the guest of honour at a dinner to commemorate the opening of a new factory, Permali Inc., at Mount Pleasant, near Pittsburgh, in the U.S.A. In his address he said that this was the 21st subsidiary company to be formed in the group.

The factory has been established to meet the increased demand for densified wood laminates from American users, a market which has been built up in spite of the high tariff duty on imports. Customers will now benefit from a better service for the supply of the basic material and machined components The works manager is Mr. A. S. Moseley who started with the firm in Gloucester before the war as an apprentice.

Part of the capital for the project has come from inhabitants in the area from a campaign organized by the local Chamber of Commerce with the slogan " Invest in Success ".

Atlas Copco—the world's largest group devoted exclusively to the manufacture of compressed air equipment—has acquired the controlling interest in Arpic Engineering S.A., of Wilrijk, Antwerp, Belgium.

Since 1946 Atlas Copco—with headquarters in Sweden—has expanded from three to twenty-six companies overseas. Such expansion has called for additional production capacity. This international group now has factories in Great Britain, Canada, South Africa and Finland.

Arpic is a Belgian organization with companies in Great Britain, Mexico and Bolivia. In 1952 they completed Europe's most modern portable compressor factory near Antwerp. They also have a plant in Scotland and a network of agents and distributors throughout the world.

The addition of the Arpic range of portable compressors to the existing Atlas series will mean that Atlas Copco can supply portable compressors with capacities ranging from 36 cfm to 550 cfm.

The General Electric Co. Ltd. and The British Tabulating Machine Co. Ltd., announce that they have entered into arrangements for collaboration in the design of efficient and competitively-priced computers and like equipment to cover the field in which such devices can be employed, and particularly the sphere of office machinery and automation.

They believe that, by collaboration in these matters and the application of the specialist knowledge and resources of both companies, significant advances in the development of these devices will be made, both in terms of design and engineering for production.

To implement this policy it is intended to form a new company, the capital of which will be held equally by the parent companies. The financial, production and distributing structure of the parent companies will not be affected by this arrangement.

The British Tabulating Machine Co. Ltd., announces that it has recently concluded arrangements with Laboratory for Electronics, Inc. of Boston, U.S.A., for the joint establishment at Boston of a Research and Development Company for the immediate purpose of completing the design and development of a Computer having certain novel features of particular interest in the business machine field. The first of such machines is due for delivery to The Chase Manhattan Bank of New York in 1957, and the second will be delivered to The British Tabulating Machine Company immediately after.

The name of the new company is International Computers Corporation, Inc.

The President will be a representative of The British Tabulating Machine Co. Ltd. and the staff will include electronic engineers from both companies, who have for some time been engaged on this project.

New Laboratory to further synthetic rubber applications. British manufacturers can expect immediate benefit from a £1 million Elastomers Laboratory which has just been opened by E. I. Du Pont de Nemours & Co., in America. The installation is designed to provide technical service on " Neoprene " and " Hypalon " synthetic rubber, and will prove an important addition to the facilities already offered by Durham Raw Materials Ltd., of 1/4 Great Tower Street, London E.C.3, the U.K. distributors of these Du Pont products.

This new Elastomers Laboratory is probably the largest and most complete unit of its kind ever assembled. It can duplicate on a pilot-plant scale many operations in rubber manufacture, and it includes separate laboratory areas for isocyanate work, adhesives, paper, dry-polymer processing, latex, physical testing and consumer-product testing. These processing and testing facilities are of the latest type for both liquid and dry rubbers.

As an indication of its scope, the new laboratory is equipped to manufacture tyre treads, apply them to carcasses, then cure and test the finished tyres. It has an experimental unit for continuous manufacture of urethane foams and a pilot plant installation for continuous extrusion of electrical wire coverings. The mill room is equipped with special rubber mills on which roll speeds and ratios can be varied, and stocks may be milled at any temperature from 50° to 350°F. The new laboratory is also set up for calendering on a production line basis. A specially built press can operate at temperatures up to 500°F for studying greatly accelerated curing rates and high-speed moulding techniques.

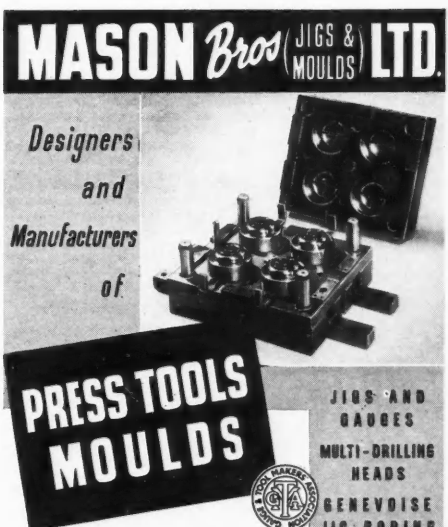
The paper area is another complete pilot-plant operation, equipped with beaters, pull-down unit, and dryers, so that paper can be made under simulated mill conditions. It was in the former Du Pont Rubber Laboratory in New Jersey that neoprene latex was first found to make a valuable additive, imparting excellent wet strength, flexibility and wear resistance to the finished paper product.

Work on colours and other rubber chemicals is another important phase of laboratory operations. Du Pont pioneered in this field in America and today offers a very wide range of such chemicals for the rubber industry. The colour room of the new laboratory is designed to ensure precise colour standardization. Particular attention is given to extreme cleanliness, and all lighting duplicates daylight conditions.

What the new Elastomers Laboratory will mean in terms of new or improved rubber products is indicated by some of its current projects:

Wire coverings, fabric coatings, white tyre sidewalls and paints are being made of " Hypalon ", Du Pont's newest synthetic rubber. Besides its remarkable chemical resistance and complete immunity to ozone—one of ordinary rubber's worst enemies—" Hypalon " can be formulated in a wide variety of colours that remain completely light-stable. This opens a whole new field of application for rubber and may lead to improvements in many existing products. A new plant for manufacture of " Hypalon " synthetic rubber is now going up at Beaumont, Texas.

Longer lasting three-elastomer tyre treads, tubeless tyre inner-liners, and tyre sidewalls, as well as elasticized concrete, cut thread for elasticized garments and automotive fuel line tubing to replace metal lines, are a few of the new developments in Neoprene. This versatile elastomer—the first general-purpose synthetic rubber to reach commercial production—still occupies the major part of the Elastomers Laboratory's activity. This year marks a quarter century of consistent growth for Neoprene. Evidence that the trend is expected to continue is the fact that Du Pont is currently building a new Neoprene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plant at Montague, Michigan, to add about 25 per cent more production capacity.

Pioneers in the field of isocyanate chemistry, Elastomers Laboratory chemists are in the forefront on development of rigid and flexible urethane foams. Taking a long-range view, they are working on urethane rubbers for such products as better tyres, flexible coatings, and shoe soles. Du Pont expects the urethane field to grow in importance, and toward that end has just put in operation a new plant to produce 25,000,000 pounds a year of " Hylene " organic isocyanates, used as intermediates in polyurethane manufacture.

The International Furnace Equipment Co. Ltd., Aldridge, Staffordshire, have concluded an agreement to represent and manufacture the products of Holcroft & Co., Inc., Detroit, Michigan, U.S.A. The agreement covers Great Britain, Australasia, and all British Colonies and Dominions, but does not cover Canada, for heat treatment furnaces. Typical applications of the equipment include carburizing, carbonitriding, clean hardening, heat treating and atmosphere generation.

Firth Brown Tools Ltd., Sheffield, have inaugurated on June 11th their new Manchester area office and warehouse at Speedicut House, Royle Street, Fallowfield, Manchester 14. Tel. No. RUSholme 7211/2/3. Stocks of an extensive range of tools are carried in the new warehouse, which will also maintain a regular delivery service in the area. Mr. P. G. Beere is the area manager.

Guests who have taken part at the inauguration and have visited the new Manchester offices and warehouse of Firth Brown Tools Ltd. received copies of *Engineers' Cutting Tools*, a most comprehensive and valuable 558 page book, describing and illustrating the multitude of cutting tools manufactured by Firth Brown Tools Ltd.

Plannair Ltd., Leatherhead, Surrey, have concluded a licence agreement with Société Air Equipement, 18 Rue Basly, Asnières (Seine), France, manufacturers of air equipment and electric motors for the aircraft and electronic industries. Société Air Equipement will manufacture the full range of Plannair axial flow blowers not only for France and French territories, but also for other European countries including Italy, Belgium, Denmark, Greece, Turkey, and Portugal.

Hoover (Washing Machines) Ltd. have recently installed at their Merthyr Tydfil factory an electrostic painting plant and electric infrared stoving ovens for the application and stoving of both primer and enamel on certain washing machine components.

As a result of this installation, paint consumption has been halved, productivity per operator doubled and a more consistent result, with fewer rejects, ensured.

Metropolitan-Vickers Electrical Co. Ltd. have supplied the infrared projectors, Fisher and Ludlow Ltd., the conveyors, and Henry Peabody (Industrial) Ltd., Birmingham, the electrostatic equipment.

The United Kingdom Optical Co. Ltd., Bittacy Hill, Mill Hill, London, N.W.7, has changed its name to U.K. Optical Bausch & Lomb Ltd. Three executives of Bausch & Lomb Optical Company of Rochester, N.Y., U.S.A., have joined the Board of the company, whose control will remain British. No change is contemplated in the present management.

Tecalemit Limited, Plymouth, Devon, announce that they have concluded a licence agreement with the Globe Hoist Company of Philadelphia, U.S.A., whereby Tecalemit will manufacture and sell Globe Car Hoists in the U.K. and all parts of the world except the U.S.A.

The Globe Hoist Company are the largest manufacturers of car hoists in the world and the new Tecalemit agreement will add substantially to the range of Tecalemit garage equipment available to the motor trade and industry, at home and abroad. One of the outstanding car hoists now made by the Globe Hoist Company and which will now be made at Plymouth, is the new Globe " Frame Kontact " car lift, that enables modern cars with independent suspension to be easily lifted wheel free for maintenance service.

The 14th British Radio Component Show, consisting of components, valves and test gear for the radio, gramophone, television, electronic and telecommunication industries, will be held in the Great Hall, Grosvenor House, Park Lane, London W.1, from 9th to 11th April, 1957, with a possible extension to 12th April. There will be a full day's preview on Monday, 8th April, for specially invited visitors. Admission is by ticket only, obtainable from the Radio and Electronic Component Manufacturers' Federation, 21 Tothill Street, London S.W.1.

CONTRACTS

Davy and United Engineering Company Limited of Sheffield have secured another large contract for the expanding steel industry in Australia.

Placed by Australian Iron & Steel Ltd., this order is worth nearly half-a-million pounds and covers the supply of extensive roller tables for a new Slabbing Mill which the Australian Company are installing at their Port Kembla Works in New South Wales.

In all, Davy-United will be supplying about 4800 tons of new machinery for this contract which is due for delivery early in 1957.

A further order has been received by **The General Electric Co. Ltd.** from the British Transport Commission for power equipments for British Railways standard 350 h.p. diesel-electric shunting locomotives. The 45 new equipments will be similar to the 15 already supplied, all of which are in service in the North Eastern Region of British Railways. The power unit consists of a Lister-Blackstone E.R. (Traction) 4-stroke, vertical 6-cylinder engine direct-coupled to a G.E.C. single-bearing main generator, on top of which are mounted an auxiliary generator and traction motor blower. The two axle-hung, nose-suspended traction motors are arranged for series or parallel connection, the grouping desired being selected by an off-load series/parallel switch in the driving cab, according to whether the locomotive is engaged on hump shunting or lighter flat shunting duties. When running in parallel, a voltage relay automatically increases the main generator excitation in suitable conditions to improve the performance at the top end of the speed range. Control of the locomotive is by variation of the main generator excitation in ten steps with the engine running at idling speed, followed by continuous acceleration of the engine to its top speed of 750 r.p.m. Mechanical parts of the locomotives will be built by British Railways.

An order worth more than £3,000,000 has been placed by the **Central Electricity Authority** with **Metropolitan-Vickers Electrical Co. Ltd.**: it covers three 120-MW steam turbine-generator sets for installation in Staythorpe " B " power station, now under construction on the north bank of the River Trent, near Newark.

The new sets will run at 3000 rpm and incorporate turbines of three-cylinder close-coupled design with steam conditions at the turbine stop valve of 1500 psig 1000°F. After passing through the high-pressure cylinder, the steam will be reheated to 1000°F and then passed through the intermediate-pressure cylinder to the double-flow low-pressure cylinder, finally exhausting to the condenser at a vacuum of 28.7 in.Hg. Six-stage feed-water heating equipment will be supplied, giving a final feed-water temperature of 436°F.

The generators are rated at 120 MW 0.8 pf and will be wound for 13.8-kV three-phase 50-c/s a.c. They will be hydrogen cooled using hydrogen at 30 psig, and the general construction will be on the same lines as other hydrogen-cooled generators supplied by the Company, the coolers being arranged horizontally in the annular space between the core and the outside of the stator frame, which will be approximately circular in cross-section. The exciter and pilot exciter will be gear-driven at 1000 rpm from the main generator shaft.

The Department of Water and Power of the City of Los Angeles has awarded a contract to **English Electric Export Trading Company Limited** for two 3-phase 18,000/140,000 volt 60 cycle 200,000 KVA power transformers together with spare parts. The contract is valued at approximately $500,000.

The transformers will be installed at the Scattergood Steam Plant, California, and will be of the forced-oil-cooled, oil-immersed, outdoor type. This equipment will be designed and manufactured at The English Electric Company's Stafford Works.

BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 2 Park Street, London, W.1.*

Code of Practice on the use of Electronic valves. CP. 1005—Part 3: 1956 covers requirements for photo-cells, transmitting valves and cold-cathode gas-filled valves.

The new part should be read in conjunction with the recommendations for all electronic valves contained in Part 1 of the Code of Practice which was published in 1954 together with Part 2.

Part 3 gives information, additional to that in Part 1, on photo-cells, transmitting valves and cold-cathode gas-filled valves ; and on the more common aspects of the use of electronic valves, such as : ratings, mountings and temperature.

Specific aspects of the subject of which the following are examples, are also dealt with : modulation-frequency response and relative spectral-response for photo-cells ; means of ventilation and cooling for transmitting valves ; and ionization and de-ionization in cold-cathode gas-filled valves. Price 3*s*.

Shaft Coupling Flanges. B.S. 2715 : 1956. Prepared at the request of the Ministry of Defence, B.S. 2715 applies primarily to internal combustion engines incorporating a coupling flange, for use with rigid and flexible shaft couplings ; but it applies also to similar applications where interchangeability of mating flanges is necessary. It does not apply to couplings used in special applications, such as overhead cranes involving heavy reversals of stress and long shafts subject to bending, nor to those covered by B.S. 664, " Cast iron shaft couplings (rigid flanged type with recessed bolt-heads and nuts) ".

The standard specifies the dimensions of shaft coupling flanges, for engine and electric motor drives, necessary to ensure interchangeability, within the range of pitch circle diameters of bolt holes from 3¼ in. to 9¼ in.

Because no interchangeability is possible where couplings with fitted bolts are used, this British Standard does not apply to shaft coupling flanges with fitted bolts.

Flange thicknesses are not specified, since this dimension will vary with the material used and with individual application. Price 2*s*. 6*d*.

Preferred standard ratings and general characteristics for 3000 rev/min, 3-phase, 50 c/s turbo-generator sets. B.S. 2730 : 1956. British Standards for steam turbines and for turbine-type electrical generators have been established for many years, but until now there has not been a standard to co-ordinate sizes of turbines and turbine-type generators and to indicate the preferred MW ratings.

B.S. 2730 specifies preferred ratings for condensing steam turbo-generator sets over a range from 10 to 120 MW. For the first part of the range, namely 10 to 30 MW, air-cooled generators are specified, while from 60 to 120 MW hydrogen-cooled generators are covered.

The principal characteristics are given for both the turbines and the generators and an Appendix deals with the determination of nominal exciter response. Price 3*s*.

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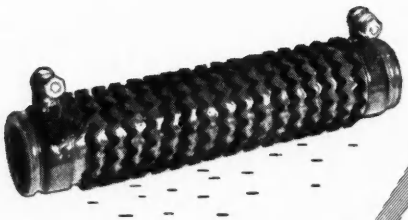

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British industry is the principal—I might well say the sole—means of support of fifty million people more vulnerable to falling sales than any people in the world. Industry needs to-day the salesman's mind and vision—backed by the skill and science of a twentieth-century advertising approach—more keenly than ever before.

This is where you come in, for the Clubs stand in an especially close and direct relationship with industry. You live right at its centre of gravity, so to speak. You know the heads and executives, you are up against the same problems, you talk the same language, you live in the same suburbs, and you serve on many of the same organizations, grave and gay. You, in the provinces, are the ambassadors of advertising to the industrial areas which employ three-quarters of the population.

Moreover, these industrial areas are the natural centres of technical advertising, or industrial advertising as I should prefer to call it. And industrial advertising is one of the biggest fields, as the estate agents are wont to say " ripe for development ".

Now I would like to add my own personal testimony to the great and growing importance of advertising by industry under modern conditions.

As Chairman of Monsanto Chemicals in this country, I shall be right in the thick of it.

Any firm offering an honest product or service, whoever it sells to, is in a sounder position for laying its foundations firmly on the widest possible public esteem. We live and work—every firm in the country—in an industrial democracy. Whether it be an educated democracy that appreciates what industry is doing for each member of it, or an ignorant democracy which doesn't know what industry means to it and half distrusts the hand that fills the pay-packet, depends, for the most part, on whether industry has taken the trouble to tell its tale properly. And by " properly " I do not mean high-pitched propaganda and bombast. The burden is right on our shoulders to tell the public at large, including our own workers and shareholders—who nowadays are widely spread over every section of society—how we contribute to the life and wellbeing of the country and what we are doing to make that contribution bigger and better. And to tell them in such a skilled and self-evidently honest way that they will read, mark—and believe.

In short, industry to-day as the nation's No. 1 Public Servant has got to prove itself at the bar of public opinion. It must explain its actions to people, capture their confidence. It is not a thing you do once and for all. Continuity is the essence. It is something that has to be done all the time, day in and day out, year in and year out, backing deeds with words.

While this is the job of public relations in its broadest sense, it is also the job of industrial advertising. Used for that purpose, they are two sides of the same penny. Moreover, it is a job which ought to go on, peace or war, because taking the people into your confidence and keeping them there is vital to the sense of unity, of pride and purpose, which makes great nations stay great.

This is not only good democracy, it is good business. It can be done co-operatively by industries or by individual firms ; better still, it can be done by both together. It is not done by pontifical preachments or solemn statements ; it is done by talking to people in their own language—the language of the people whom advertising is in business to address, with wit and truth, good sense and good humour.

I am well aware that there are people, many of them in industry, who dismiss the idea of a public information policy as a part of industrial advertising as a waste of money. They say it is prestige advertising and that prestige advertising is an airy-fairy frill ; all right, no doubt, for those who wear their hair long, but unworthy of hard-headed men who are in business to make pennies breed. To that, with all due respect, I say " Rubbish "! The people who think that way about prestige advertising, it is fairly safe to say, are those who don't know what it means or have never used it rightly. The best testimony to its worth is to be found in the firms that use it, in their balance-sheets, in their fame as household words, in the affection and respect they command both inside and outside the business.

The latest figures for industrial advertising, unfortunately now about three years old, show that we have some way to go before we catch up even to its pre-war ratio to sales.

We all know why. For about 10 or 12 out of the last 15 years we have suffered from over-full order books and over-full employment. I say " suffered " because living on velvet softens up the sales muscles and hardens the sales arteries and in industrial advertising in particular it gives all those people—and they are still quite numerous, who believe that good goods sell themselves and that advertising is unnessary, the chance to say how right they are. And that is very, very dangerous for a country in the position of Britain.

But we need not only more advertising to match up to the vastly increased output of goods and services, we need better and more imaginative advertising to achieve the aggressive growth of British industry, particularly in the export field, without which we shall presently sink into the faded gentility of a second class nation.

When we talk of the need for more imaginative industrial advertising I mean above all the imaginative use in the industrial field of the immense new resources which advertising in general has applied with such conspicuous success, in the field of consumer advertising. They fall into three main groups : the imaginative use of colour and design which draws freely on all the art developments of the last 50 years ; the imaginative approach to the art of using words that persuade ; finally, the imaginative use of statistics, research and psychology.

These three groups make up what one might call the Grand Alliance of modern advertising—an alliance devoted entirely to penetrating what Lord Woolton recently called " the mystery of the mind of man ". After all, the mind of man is the battlefield on which sales as well as causes are lost or won. And reasons for one or the other may as often—or oftener—be subjective as objective, which serves to deepen the mind's mystery still further. So we take it for granted in modern business that the market situation should be explored and mapped in detail and in depth. We take it for granted that we must know and keep on knowing what customers are thinking about our product and our competitors' products, what wholesalers and retailers are thinking, and why they think the way they do. With this information we can turn the flank of sales resistance. And, at the same time, we may find out valuable things about our product which we should otherwise never have known.

There are plenty of firms in Britain, big and small, who know all this very well, have been doing it for years and have been shooting rapidly ahead as a result. But there are others who don't and aren't. For the most part they are to be found in the solid middle group, which has managed to get on very well without much or any advertising in the past, doesn't see the need for it now, and, if the truth is told, doesn't really believe in advertising at all. When a firm like that does get around to advertising, it goes about it, all too often, in a way which ensures that the money is wasted and its disbelief in advertising is justified to the full. Like a man taking a bottle of medicine which the doctor has prescribed but which he is quite sure will do him no good.

It is time we all recognized that we have had, over the last 15 years, a surfeit of emphasis on production and the resultant hangover is thoroughly bad for our industrial health. It is time we said again that production is a liability and a danger unless it can be sold.

Mr. Butler said a year or so ago that we could double our standard of living in 25 years. We could do it long before then, if production alone were what it depended on. But it doesn't ; it depends, among other things, on the stimulation of demand, the desire as well as the power to consume. On advertising, not least.

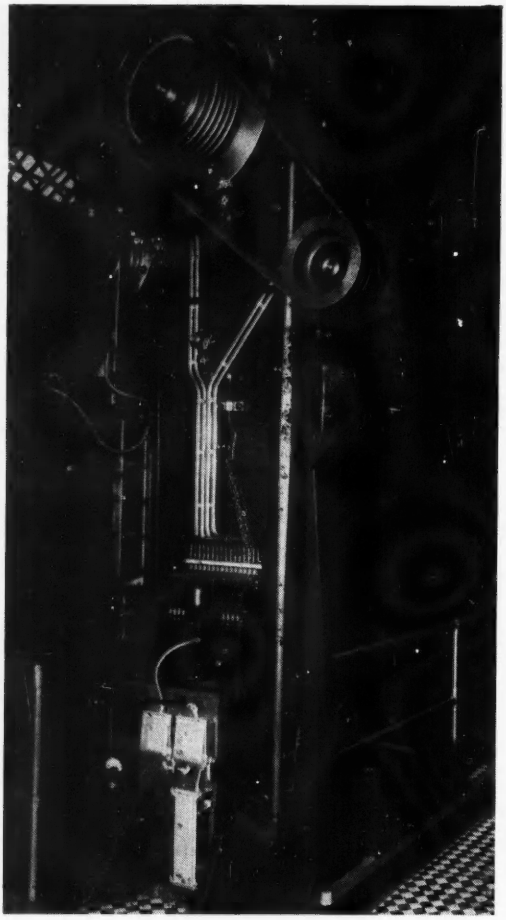
Don't tell me that the public, or even industrialists, know all this perfectly well, for they don't. Or if they do, they conceal the evidence with remarkable skill. We see on every hand politicians, leaders of industry, educationalists and others writing letters to the Press and making speeches to point out how vital it is that we should train more technicians for industry to invent the processes and understand the gadgets and tend the infinitely complicated machines which the age of automation is going to produce. And how right they are.

But where do we see anyone calling, least of all in high places, for that other large body of men—not one whit less decisive—who are going to sell these goods at home and all over the world, and create the inspired and imaginative publicity which is such a vital tool of any effective sales policy? Where do we see the demand for men with genius and training—and the impulse and conviction—to penetrate the mysteries of the minds of a world three thousand million strong ? Yet without these skilled salesmen and advertisers all the productive skill in the world, of which in Britain we have at least our fair share, if not more, is about as useful as playing an accordion for pennies to an audience of deaf men.

One of the radical changes we have got to bring about in this country—and time is NOT on our side—is an alteration in the traditionally rather sour and superior attitude to advertising and selling. I have been a salesman all my life and I say it with pride because, in the modern world, sustained by mass industries, production starts with demand, not demand with production. I learned that lesson very well when as a young man I became aware of the power of the Press and publicity to promote the mass sales of popular cars. The same lesson was rammed home when, later, as head of publicity for the Morris organization it was my job to create the conditions which would see to it that the space at the end of the assembly lines was kept clear for the new cars as they rolled off. My experience since has steadily strengthened my conviction. The nearer one finds oneself to the head of a business the more vital does one see the selling effort to be ; vital, not simply to the prosperity of the business, its bosses and its shareholders, but vital no less to the prosperity and pay packets of the office and factory staff, the local tradesmen from whom they buy their needs, the bus companies that carry them, the cinemas that amuse them and the wellbeing of their children who fill up the classrooms at the bright new local schools. The whole load falls fair and square in the last resort on the success of the people who know how to advertise and sell. It follows that advertising and the people who practise it are already vital to any civilization we are prepared to call worth while, and are in a fair way to become more so. They are as vital in their own sphere as doctors and lawyers, teachers, accountants and managers and an efficient and incorruptible civil service are in theirs. We have long accepted these bodies and professions without question as necessary, but in fact they are no more necessary than advertising to modern life, any more than chisels are more necessary than spanners or screwdrivers. They have been with us longer, that is all. We have had more time to get used to them and to understand their worth.

We have got to get this common sense view across, inside industry, and outside industry to the public at large. This means you in the Clubs. If you don't do it, no one else will, or can. It just cannot, in practice, be done by remote control from Bell Yard.*

* Headquarters of The Advertising Association.



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The ' Brentford ' system of continual lubrication is entirely automatic. It is extremely versatile since each pumping unit—and there are from 1 to 24 of these—can be adjusted individually to deliver the right amount of oil to every bearing.

One pumping unit is used on each line or lubrication point, and the pump capacities are 1, 3 or 8 pints of oil. The ' Brentford ' can be driven in two ways; reciprocal or rotary off the machine or from its own Motor and Reduction Gear Box.

' Brentford ' Automatic Lubricators are at work in almost every industry, on many kinds of machine. Reductions in breakdowns have been estimated as up to 80%, with resultant increases in production and safety, and savings in the oil and power used.

The ' Brentford ' is one of the wide range of lubrication systems produced by Tecalemit and used throughout industry.

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SITUATIONS VACANT

VICKERS-ARMSTRONGS LIMITED,
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Are being made the main contractors by the Admiralty for the first set of machinery for marine propulsion utilizing nuclear energy. They are seeking technical staff, as under, for work at Harwell :

PHYSICISTS

Experimental Physicists with Honours Degrees in Classical Physics.

Experimental Physicists holding H.N.C. or G.C.E.

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Men holding Honours or Pass Degrees in Mechanical Engineering with some experience in industry. In addition there are vacancies for assistants holding H.N.C. in Mechanical Engineering and who have served an apprenticeship.

DESIGNERS

Men having design experience, and holding Honours or Pass Degrees in Mechanical Engineering, and having practical experience, preferably in Marine Engineering, or on the technical side for the generation of power for use on land.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes.

Applications, giving full details, should be sent to the above address.

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED
BARROW-IN-FURNESS, LANCASHIRE

Are seeking technical staff, as under, for research and development work in connection with the application of new methods to the propulsion of ships.

ENGINEERS

Engineers holding Honours Degrees with experience in the field of marine or mechanical engineering.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes, and the production and installation of machinery.

TEST ENGINEER

For marine research work. A minimum standard of H.N.C. is required, and sea-going experience with Board of Trade Certificate will be a distinct advantage.

The above requirements offer a splendid opportunity to the right type of men, and good salaries will be paid in accordance with experience, ability and training.

The Barrow district is an extremely pleasant one in which to reside, offering the close proximity of sea, countryside and the Lake District. In suitable circumstances, housing accommodation may be available if required by successful applicants, and a contributory pension scheme is in operation.

Sporting and social facilities are excellent, providing a wide variety of activities on a large and well appointed sports ground.

Applications giving full details, should be sent to the Labour Manager at the above address.

MATHEMATICIAN required for a post in connection with the analysis of process control systems and servo-mechanisms.

Applicants should preferably have a degree in Electrical Engineering or Physics, and have had experience on such work. A knowledge of servo theory is of advantage. Successful applicant will be required to use analogue and digital computation for his work. The post is permanent and pensionable.

Apply for Application Form, quoting reference " K.5.", to :

Personnel Manager,
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IMPERIAL CHEMICAL INDUSTRIES LIMITED
METALS DIVISION

METALLURGISTS, PHYSICISTS
and
MECHANICAL ENGINEERS

Applications are invited for several interesting positions in the RESEARCH DEPARTMENT at Birmingham. The successful applicants would be required to assist investigations in a wide variety of research projects concerned with non-ferrous metals and alloys. Candidates should possess either a degree, Higher National Certificate, or an equivalent professional qualification in either Metallurgy, Physics or Mechanical Engineering, and must have fulfilled their National Service obligations.

These positions offer a generous starting salary, dependent upon age, qualifications and experience, and there is adequate scope for progressive remuneration. The Company operates both Pension and Profit Sharing Schemes and married men will receive a reasonable refund of removal (including travel) expenses.

Applications should be addressed to the Staff Manager, Imperial Chemical Industries Limited, Kynoch Works, Witton, Birmingham 6, quoting RES/20/ED.

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If having completed your National Service you are graduating this year in either Engineering or Physics, or if you already possess these or similar qualifications, you may be interested in the following opportunities in our RESEARCH DEPARTMENT at Birmingham, offering the most up-to-date facilities available for studying the problems of the non-ferrous metals industry.

MECHANICAL ENGINEERS are required to undertake fundamental and practical research work in the rolling, drawing and extrusion of copper, aluminium, titanium and associated alloys. Suitable small scale research plant is available but investigators will be given ample opportunity to study the performance of existing production plant and to apply the results of their researches to such plant.

PHYSICISTS are required to devise, design and apply apparatus for the measurement of properties of non-ferrous metals and alloys. This work calls for inventiveness and initiative in the practical application of classical physics to a variety of research problems.

Candidates should preferably, but not necessarily, be under 30 years of age. Whilst relevant experience would be advantageous it is not essential.

These positions offer generous starting salaries, dependent upon age, qualifications and experience, and there is adequate scope for progressive remuneration. The Company operates both Pension and Profit Sharing Schemes, and after joining the staff married men may receive a reasonable refund of removal (including travel) expenses, together with loans in approved cases, to assist them in house purchase.

Application forms or further information may be obtained from :

STAFF MANAGER,
Imperial Chemical Industries Limited
Metals Division,
Kynoch Works, Witton, Birmingham 6.

CAPACITY

CAPACITY AVAILABLE FOR CENTRE LATHE, CAPSTAN, MILLING AND DRILLING WORK; PRODUCTION OR TOOL WORK. SPECIALISTS IN FINE LIMITS. FOR PARTICULARS WRITE OR CALL SHEERWATER MOTOR CO. LTD., OSYTER LANE, BYFLEET, SURREY. 'PHONE: BYFLEET 3630.

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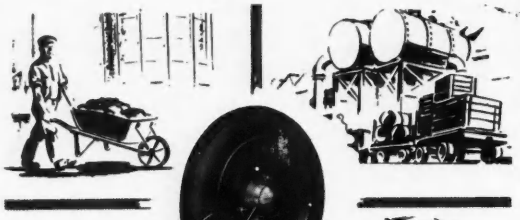

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Hughes have had over eighty years' experience of wheel and castor manufacture. If you've a handling problem, just let us know the proposed uses, loads and working conditions—we'll be glad to advise you on the best wheels for the job.

Illustrated is the N/SS 12" wheel with Roller Bearing and Cap.

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You'll never find a Lewis Spring suffering from debility or that couldn't-care-less feeling. A lively Lewis Spring never rests, never tires. You can learn a lot about them and about springs in general if you send 2s. 6d. for our 40-page manual on spring design, full of technical data.

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BOOKS RECEIVED

Engineering Drawing and Geometry. By Randolph P. Hoelscher and Clifford H. Springer. 515 pp., 1076 illustrations. Publishers : John Wiley & Sons, Inc., New York, and Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price : 64/–.

Modestly described as a " modern, scientific approach to both engineering drawing and engineering (or descriptive) geometry ", this truly magnificent book, superbly conceived and illustrated, may well be considered a *vade-mecum* of the subject. The authors, Professors of General Engineering at the University of Illinois, are to be congratulated on their style and presentation, providing as they do a text clear enough in its verbal discussion and pictorial illustrations to be easily understood by students, but which, at the same time, present the best in draughting practice and emphasize the development of reasoning processes.

The book, which uses a large size of page, permitting larger and clearer illustrations, covers the subject completely, and includes chapters ranging from the use and care of instruments, lettering, and geometrical constructions to geometric, orthographic, auxiliary, axonometric, and oblique projections, sketching, perspective, sectional views, and dimensioning. In addition, there are comprehensive chapters dealing with map, architectural, structural, pipe, machine, tool, welding, and Patent Office drawings, and with the reproduction of drawings, fasteners, shop terms and processes, drawings for interchangeable assembly, charts and diagrams, etc. A useful index and a comprehensive appendix of tables, gauges, etc., are appended.

Design of Piping Systems. 2nd Edition, 1956. 380 pp., 180 illustrations. Publishers : John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price : 120/–.

When the first edition of this work, published privately by the M.W. Kellogg Company in the U.S.A., first appeared in 1941, it made available for the first time an adequately organized, comprehensive analytical method of evaluating stresses, reactions, and deflections in an irregular piping system. This approach, now widely known as the Kellogg General Analytical Method, made it possible to provide satisfactory design for the large number of critical and pioneering piping requirements associated with World War II plant design.

As a result of the latest developments and extended experience in this field, this new edition has been published. It supplements Code rules and other readily available information with specific mechanical design approaches for entire piping systems, as well as their individual components, and provides a background which will engender understanding and competent application of analytical results. As a result, the opening chapter deals concisely with the physics of materials. This is followed by a comprehensive study of the capacity of piping to carry various prescribed loadings. The utilization of materials is then considered, not only in relation to fundamental knowledge but also on the basis of conventionally accepted practices. The present edition, which is written mainly by members of the engineering departments of the M.W. Kellogg Company, also includes a greatly augmented treatment of local flexibility and stress intensification, together with a chapter on simplified methods of flexibility analysis, containing several newly developed approaches which should prove helpful for general assessment of average piping, or in the planning stage of the design of critical piping. Furthermore, the Kellogg General Analytical Method, now extended to include all forms of critical piping loading, has been improved in presentation by the use of numerous sample calculations to illustrate application procedures, and by placing the derivations of the formulae in an appendix. Finally, the rising significance of vibration is dealt with in a special chapter, while other chapters cover expansion joints and pipe supports, offering what is believed to be the first broad treatment of these items with regard to critical piping.

LATEST INDUSTRIAL LITERATURE

1. **Guide to Screw-Thread Forms.** A well-produced and tabulated guide shows, at a glance, the multiplicity of screw threads throughout the world, 60 forms of which are illustrated, while no less than 146 series from 21 countries are indexed, together with the reference numbers of relative National Standards. Alternative descriptions by which some threads are known are also given. The layout has been designed to show not only all these thread forms together for easy comparison, but also to group them specially for varying requirements. Furthermore, the guide is suitable for wall mounting, as well as for desk use or for reference libraries, while colour has been judiciously used to aid the eye.

2. **Plastic/Chrome-Leather Laminated Belting.** Incorporating a tough, resilient, load-bearing plastic, a new chrome-leather belting, described in a 6-page illustrated brochure, is designed for efficiency and long life. The bonding of the plastic to the chrome leather ensures that the belting is permanently non-stretching under the most severe conditions. Furthermore, this belting is stated to be nine times stronger and only a quarter of the weight of leather, permitting it to transmit higher powers at far greater speeds (with far less power consumption) for a much greater period than ordinary belting. Other advantages include the fact that it is virtually noiseless, non-slipping, and gives a positive drive, while the plastic centre absorbs shock loads and reduces loss of power and speed.

3. **Machine Vices.** In a neatly produced and illustrated booklet, details are given of a range of sturdy and rigid machine vices for production work. These vices have easily removable jaws, alternative types of which are available, which can be quickly adapted either for holding components of diverse shapes, or as a basis for efficient and inexpensive jigs. These jaws, which are of the sliding ram type, grip firmly without lift or spring, and no fine adjustment is necessary to maintain a correct fit of the slide in the body of the vice. Moreover, the sides of the base are machined parallel and square with the jaw faces and extend the full length of the body, thus facilitating setting on the machine table.

4. **Stainless-Steel Tubes.** In a beautifully produced and illustrated 28-page catalogue, details are given of a comprehensive range of stainless-steel tubes, ranging from $\frac{1}{8}$ to 6$\frac{1}{8}$ in. in diameter, and in thicknesses down to 22-gauge. Normal random lengths are supplied with a variation of 6 ft, but tubes can be supplied cut to specified lengths. Illustrated examples of the applications of these tubes in a wide range of industries are also given, including the dairy, brewing, food, chemical, and textile industries, and for general and decorative purposes.

A supplementary catalogue covers a comprehensive range of stainless-steel tube fittings.

5. **Shallow Hardening Steel.** As described in a 6-page brochure, a 1% carbon steel, produced in the arc furnace by a special technique, has especially high hardness values obtained on the case after quenching, and uniform depth of this hardness, irrespective of the thickness of the section, down to $\frac{1}{16}$ in., at which point the hardness penetration is practically through. This steel is supplied in easily machineable condition and, after heat treatment, is eminently suitable for tools and components subject to severe abrasion, shock, and deformation.

6. **Abrasive-Band Equipment.** Details are contained in an illustrated pamphlet of wet abrasive-band equipment designed to meet the requirements of the plastics, glass, and ceramics industries, and also applicable to the finishing of metallic components where fine finish, coupled with rapid cutting action, is required. These machines are made in a wide variety, depending on application, and filtration of the coolant can be incorporated, where necessary.

Also described in this pamphlet is a small, but versatile, abrasive-band machine which, by using the wide range of different attachments available, can be employed in a large number of operations. Certain of the attachments can actually be used simultaneously, while the column of the machine is free to rotate through 360 deg., so that it may be located in the most convenient working position.

7. **Automatic Control and Protection of Diesel Engines.** Details are contained in a 4-page brochure of equipment for the automatic control and protection of diesel engines. Several standard schemes for automatic protection and alarm indication are available, together with standard designs for many comprehensive control panels, some of which are illustrated in the brochure.

This automatic equipment, which gives warning of dangerous engine conditions, is controlled by switches sensitive to pressure, temperature, speed, or level variations. These items can also be supplied, in addition to the control panel, which includes all relays and alarm indicators, switches, and fuses.

8. **Flame Planers.** Details are contained in a neatly produced and illustrated 16-page brochure of two types of flame planers, by means of which it is possible to prepare all four sides of a plate simultaneously and to obtain any of the following plate-edge preparations : Vertical cut, single bevel, single bevel and root face, double bevel, and double bevel and root face.

The larger of the two types described is designed to give an exceptionally high degree of accuracy and an outstanding rate of production, with plates of any length and up to 11 ft in width. The smaller model, though no less accurate, is not quite as speedy, and can be used with plates of any length and up to 10 ft in width.

9. **Fans, Blowers, and Exhausters.** In a well-produced and profusely illustrated 40-page booklet, details are contained of a comprehensive range of fans, blowers, and exhausters for a wide variety of applications, including centrifugal, paddle-type, multivane-type, backward-blade-type, " Monogram "-type, axial-flow, and propeller fans, furnace hot-gas fans, acid-fume fans, gas boosters and gas-plant blowers, turbo-blowers and exhausters, and rotary piston blowers and exhausters. In addition, chapters are included on the subjects of fan design and construction, and fan application and selection, together with tables and charts of standard pressure measurements, circular equivalents of rectangular ducts, pressure drop in duct fittings, and dust friction.

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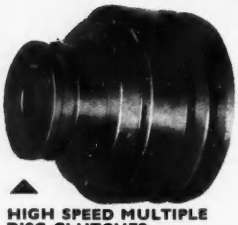

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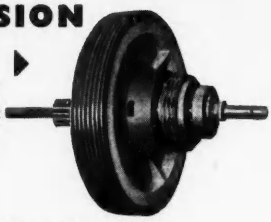
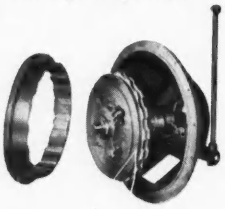
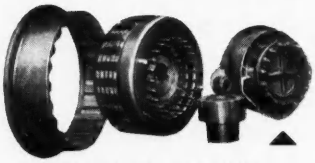


FLEXIBLE COUPLINGS
This Elliptical Rubber Buffer Flexible Coupling is extremely efficient, the two shafts are free to move axially and the shape and flexibility of the Rubber Buffers ensure that even pressure is exerted by each Driving Lug. Suitable for either direction of rotation.

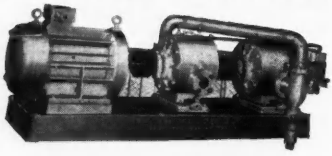


POWER TAKE-OFF CLUTCH ASSEMBLIES
Complete self-contained units for Diesel and Petrol engines to drive all kinds of machinery. Range of sizes to suit medium and large powers and speeds.

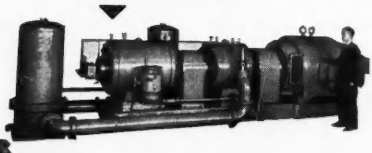


CLUTCH-BRAKE ASSEMBLIES
The illustration shows a pneumatic Clutch-Brake Assembly supplied for a 500 ton Forging machine. Duty 1,100 h.p. at 42 r.p.m. frequency 3-4 strokes per minute.

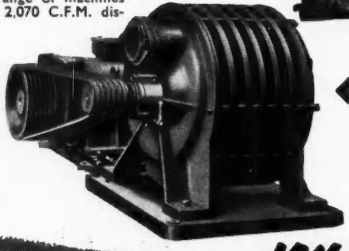
...AND AIR/GAS HANDLING PLANT



ROTARY AIR COMPRESSORS
Two-Stage Rotary Compressors having a free air capacity of 1,000 C.F.M. at 100 lb./sq. in. pressure. Full range of machines available up to 2,070 C.F.M. displacement.



ROTARY VACUUM PUMPS
Two-Stage Rotary Vacuum Pump. 290 C.F.M. displacement, 29.98 in. H.C. Full range of machines available up to 2,070 C.F.M. displacement.



TURBO BLOWERS AND EXHAUSTERS
Range available up to 7½ lb./sq. in. pressure and 10 in. of Mercury Vacuum.

Whittaker Hall

WHITTAKER HALL & CO. (1929) LIMITED

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